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Economics of Disposal of Lime/Limestone Scrubbing Wastes: Untreated and Chemically Treated Wastes

National Fertilizer Development Center, Muscle Shoals, Ala

Prepared for

Industrial Environmental Research Lab -Cincinnati, Ohio

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National Fertilizer
Development Center
Muscle Shoals, Alabama 35660

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Industrial Environmental Research
Laboratory
Research Triangle Park, North Carolina 27711

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February 1978

ECONOMICS OF DISPOSAL OF LIME/LIMESTONE SCRUBBING WASTES: UNTREATED AND CHEMICALLY TREATED WASTES

Interagency
Energy-Environment
Research and Development
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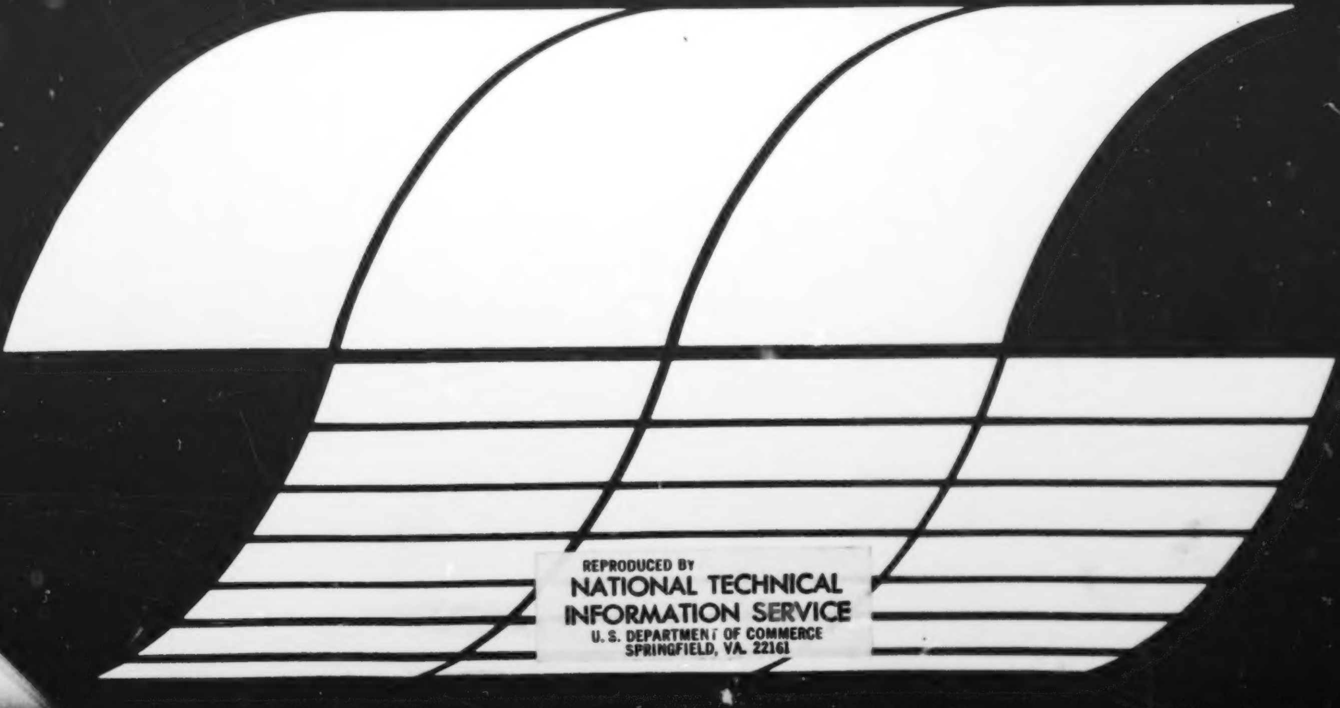

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Sludge Disposal	Desulfurization	Stationary Sources	07A	07D
Economic Analysis	Electric Power Plants		05C	
Calcium Oxides			07B	10B
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ABSTRACT

A study was conducted to provide a detailed, comparative economic evaluation of four alternatives available to the utility industry for the disposal of wastes produced from flue gas desulfurization (FGD) using limestone or lime slurry scrubbing. The four disposal alternatives evaluated were untreated sludge (pond or landfill) and sludge chemically treated by three different commercial processes--Dravo Corporation's Synearth process (pond and landfill), I.U. Conversion System's Poz-O-Tec process (landfill), and Chemfix's ultimate disposal process (landfill). The processes were assumed to be technically proven and applicable to full-scale installations.

Design and economic premises for the power plant, scrubber system, and sludge disposal systems were established and used, along with the latest available technology, to prepare (1) material balances, (2) equipment lists and specifications, (3) capital investments, and (4) revenue requirements for a base case system for each alternative. The base case was a new 500-MW power plant burning coal with 3.5% sulfur, 16% ash, and 10,500 Btu/lb heating value. A limestone wet scrubbing FGD system (1.5 stoichiometry) was used to remove flyash and SO_2 to meet New Source Performance Standards. Underflow from the scrubber system to the waste disposal system is a 15% solids slurry. The effects of power plant size and remaining life, coal analysis, scrubber process, distance to disposal site, fixation additive rate, and mode of transportation were considered. A total of 121 variations of system design and operation was prepared for the alternative processes. Total capital investments, annual revenue requirements, and lifetime revenue requirements for power plants operating over both declining- and constant-load 30-yr profiles are included for the 121 cases. Capital investments are based on mid-1979 costs and revenue requirements, mid-1980. A 3-yr construction schedule is assumed for a midwestern plant location.

Capital investments range from $10,717,000 ($21.4/kW) to $24,114,000 ($48.2/kW) for the four base cases. Base case annual revenue requirements are between $3,280,000 (0.94 mills/kWh) and $6,988,000 (2.00 mills/kWh). These costs can be combined with the base case FGD system costs (500-MW, new plant, etc.) to yield the total FGD-waste disposal system costs. The FGD system costs without any disposal provisions are (1) capital investment of $36,368,000 ($72.74) and (2) revenue requirements of $11,841,500 (3.38 mills/kWh). The investments and revenue requirements vary considerably for the 121 case variations. The most economical disposal alternative for a particular power plant cannot be chosen by using generalities since the costs are dependent upon site-specific variables, such as plant size, remaining life, land availability and cost, coal analysis, and disposal system location.

This report was submitted by the Tennessee Valley Authority, Office of Agricultural and Chemical Development, in partial fulfillment of Energy Accomplishment Plan 79-BBI under terms of Interagency Agreement EPA-IAG-D8-E721 with the U.S. Environmental Protection Agency. Work was completed as of June 1977.

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GLOSSARY, ABBREVIATIONS, AND CONVERSION FACTORS

GLOSSARY

Cementitious: A chemically precipitated binding of particles resulting in the formation of a solid mass.

Fixation: The process of putting into a stable or unalterable form.

Impoundment: Reservoir, pond, or area used to retain, confine, or accumulate a fluid material.

Leachate: Soluble constituents removed from a substance by the action of a percolating liquid.

Leaching agent: A material used to percolate through something that results in the leaching of soluble constituents.

Pozzolanic reaction: A reaction producing hydraulic cement or a similar material.

Stabilization: Making stable by physical or chemical treatment.

ABBREVIATIONS

Btu	British thermal unit
cm	centimeter
cm/sec	centimeter per second
^oC	degrees Centigrade
^oF	degrees Fahrenheit
ESP	electrostatic precipitator
FGC	flue gas cleaning
FGD	flue gas desulfurization
ft	feet
ft/sec	feet per second
g	gram
gal	gallon
gpm	gallons per minute
hp	horsepower
hr	hour
in.	inch
j	joule
j/s	joule per second
k	thousand
kg	kilogram
km	kilometer
kW	kilowatt
kWh	kilowatthour
l	liter
lb	pound
M	million
m^2	square meter
m^3	cubic meter
MW	megawatt
ppm	parts per million
psi	pounds per square inch
sec	second
TDS	total dissolved solids

CONVERSION FACTORS

To convert from English units	To metric units	Multiply by
acre	hectare	0.405
barrels of oil	liters	158.97
British thermal unit	gram-calories	252
degrees Fahrenheit-32	degrees Centigrade	0.5555
feet	centimeters	30.48
square feet	square meters	0.0929
cubic feet	cubic meters	0.02832
feet per minute	centimeters per second	0.508
cubic feet per minute	cubic meters per second	0.000472
gallons	liters	3.785
gallons per minute	liters per second	0.06308
grains (troy)	grams	0.0648
grains per cubic foot	grams per cubic meters	2.288
horsepower	kilowatts	0.7457
inches	centimeters	2.54
pounds	kilograms	0.4536
pounds per cubic foot	kilograms per cubic meter	16.02
pounds per hour	grams per second	0.126
miles	meters	1609.
revolutions per minute	radians per second	0.1047
standard cubic feet per minute (32°F)	normal cubic meters per hour (0°C)	1.695
tons (short)[a]	metric tons	0.90718
tons (long)[a]	metric tons	1.016
tons per hour	kilograms per second	0.252

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a. All tons, including tons of S, are expressed in short tons in this report.

ECONOMICS OF DISPOSAL OF LIME-LIMESTONE SCRUBBING WASTES: UNTREATED AND CHEMICALLY TREATED WASTES

EXECUTIVE SUMMARY

Emission standards for coal-fired power plants promulgated by the U.S. Environmental Protection Agency (EPA) under the Clean Air Act have made necessary the installation of systems for flue gas cleaning (FGC). Flue gas desulfurization (FGD) by the lime-limestone wet-scrubbing method is the most advanced technology for SO_2 removal and at least 90% of the full-scale FGD systems existing or under construction are lime-limestone processes (1).

Use of the lime-limestone process results in the production of very large quantities of calcium-based waste materials (sludge) that must be disposed of within the constraints of land and water quality regulations.

Many research and development efforts have been centered around the sludge disposal problem associated with FGD and a number of these efforts have been funded by EPA (2). The EPA efforts in the FGD sludge area are part of a program titled "Control of Waste and Water Pollution from Combustion Sources," or simply "Waste and Water Program." These efforts were designed to evaluate, develop, demonstrate, and recommend environmentally and economically acceptable methods for disposal and utilization of FGC waste. The FGC waste efforts of the EPA program encompass the following major areas of interest:

- Environmental assessment of FGC waste disposal and utilization processes
- Assessment of process technologies
- Studies of process economics
- Development of alternative methods for FGC waste disposal
- Development of FGC waste utilization methods

This study is within the category of process economic studies. The study provides a detailed economic evaluation of disposal practices which are either currently used by the utility industry or are potentially applicable to the utility industry.

The disposal of FGD sludge is usually in a landfill or pond. However, before disposal, the material may be subjected to a number of mechanical and chemical treatments which include dewatering and chemical fixation. Several processes are currently being used by utilities or being marketed by vendors to utilities for the disposal of FGD sludge. Four processes considered to represent the wide range of available alternatives were selected for evaluation in this study. These processes are untreated disposal and treated disposal methods developed by Dravo Corporation, IU Conversion Systems, Incorporated (IUCS), and Chemfix, Incorporated (a division of the Carborundum Company).

The base case for the untreated sludge disposal option is for the direct ponding of wastes in a clay-lined pond located 1 mi from the scrubber facilities. A total of 40 case variations including dewatering, landfill disposal, transport by truck, and distance to the disposal site were studied.

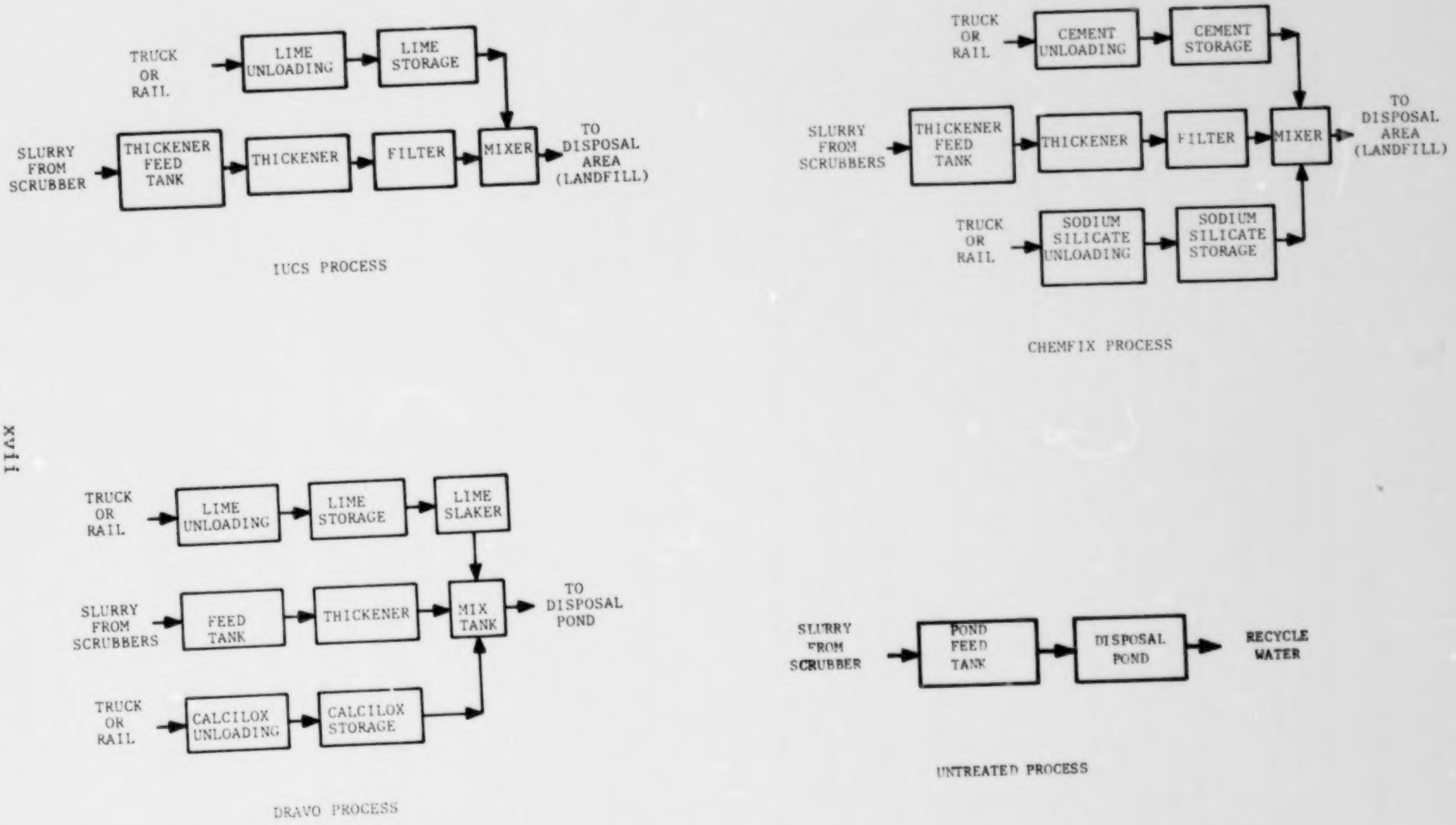
The base Dravo system is for pond disposal of treated, partially dewatered (35% solids) sludge. The final product is reported to be a soillike material that can be mechanically handled and can support varying loads depending on the degree of stabilization resulting from chemical treatment. The base IUCS and Chemfix systems, which chemically differ in the types of stabilization additives, are for landfill disposal of a soillike material. The scrubber system effluent (15% solids) is dewatered, using a thickener and rotary drum filter, to a sludge material containing 60% solids. Chemical fixation additives are mixed with the dewatered sludge to produce a chemically and mechanically stable material. The fixed sludge can be easily handled, hauled by truck, and compacted to meet the needs of the utility, depending on geographical location, land availability, and disposal regulations. A total of 80 case variations for these three treated sludge disposal alternatives were evaluated.

The objective of this study was to prepare detailed estimates of total capital investment and annual revenue requirements for each disposal alternative including case variations of significant process parameters. Since these processes are being used in either demonstration- or full-scale application, information is available for defining the necessary equipment and establishing accurate cost-size relationships. Although the cost estimates for the various systems are not considered absolute for site-specific conditions, they have uniform bases and, therefore, can be subjected to a general economic comparison and evaluation.

PROCESS BACKGROUND AND DESCRIPTION

The four disposal processes are briefly described in the following discussion. Specific data concerning the design of these systems, along with the necessary proprietary information for evaluating these designs, were obtained from the company marketing the process. Figure S-1 shows simplified process flow diagrams for the four alternatives.

Several assumptions such as FGD system effluent solids (15%), pond settling (50% solids), thickener dewatering (35% solids) are reported for the four alternatives evaluated. The values used are based on pilot- or demonstration-scale test work and do not necessarily represent actual operating conditions for any specific installation or the limits of capability for a particular site.


TRUCK OR RAIL
LIME UNLOADING
LIME STORAGE
SLURRY FROM SCRUBBER
THICKENER FEED TANK
THICKENER
FILTER
MIXER
TO DISPOSAL AREA (LANDFILL)
IUCS PROCESS
TRUCK OR RAIL
CEMENT UNLOADING
CEMENT STORAGE
SLURRY FROM SCRUBBERS
THICKENER FEED TANK
THICKENER
FILTER
MIXER
TO DISPOSAL AREA (LANDFILL)
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SODIUM SILICATE STORAGE
CHEMFIX PROCESS
TRUCK OR RAIL
LIME UNLOADING
LIME STORAGE
LIME SLAKER
SLURRY FROM SCRUBBERS
FEED TANK
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TO DISPOSAL POND
TRUCK OR RAIL
CALCILOX UNLOADING
CALCILOX STORAGE
DRAVO PROCESS
SLURRY FROM SCRUBBER
POND FEED TANK
DISPOSAL POND
RECYCLE WATER
UNTREATED PROCESS

Figure S-1. Simplified flow diagram for four disposal alternatives.

Untreated Sludge Disposal

Effluent from the scrubber system can be (1) directly ponded, (2) dewatered and ponded, or (3) dewatered and chemically treated for pond or landfill disposal. The disposal of sludge that has not been chemically treated is one of four disposal alternatives considered in this study. Direct ponding of scrubber effluent (15% solids) in a clay-lined pond is a common alternative used by the utility industry. This system, the simplest alternative, requires a minimum amount of additional equipment as compared to other disposal alternatives, but the investment for a disposal pond can be very large. The ponded sludge settles to a 50% solids material and excess water is returned to the scrubber system. Some utilities are not lining the disposal pond. Other industries are using a variety of synthetic linings for lining waste disposal ponds. In all ponding cases, local ground and surface water should be monitored for contamination by leachate from the disposal pond. Settled sludge containing more than 40% moisture is not structurally stable and is often covered with water to improve safety and aesthetic requirements.

Thickeners may be used for dewatering untreated sludge (from 15% solids slurry to 35%) to reduce the quantity of material for pumping to the pond. Additional dewatering is sometimes used to yield a 60% solids material that is assumed to be suitable for handling belt conveyors, trucks, and earthmoving equipment. This material is assumed suitable for landfill disposal.

Dravo Process

The product for disposal is a chemically treated slurry which contains 35% solids and can be pumped to a disposal pond. The ponded material upon settling contains about 50% solids, and with 15-30 days of curing, is reported to stabilize as a soillike material. Excess water is returned to the scrubber systems. Effluent from the scrubber system is dewatered to form a 35% solids slurry using a thickener and pumped to an agitated mix tank where Dravo's chemical fixation agents (Calcilox and Thiosorbic lime) are added. These agents and the entire fixation process are patented (called the Synearth process) (3).

The additives (Calcilox at an amount of 7% by wt of dry sludge solids and Thiosorbic lime at an amount of 1%) combine with sludge components in cementitious reactions that result in the formation of a crystalline-interlacing structure of molecules that tie up free water resulting in stabilization of the sludge material (4).

Dravo offers another process that involves intermediate ponding of treated 35% solids sludge in small (15-30 day capacity) curing ponds. The stabilized, soillike sludge is then taken from the curing ponds and is suitable for handling with belt conveyors and can be hauled by truck to a landfill for placement and compaction.

IUCS Process

The proprietary process offered by IUCS for stabilization of FGD sludge is marketed as the Poz-O-Tec process. Sludge is dewatered with a thickener and rotary drum filter to form a cake containing 60% solids; stabilization is then accomplished by mixing this cake with the IUCS additive lime (5). Flyash is a necessary ingredient for stabilization and, according to IUCS, can be either removed with the sludge slurry from the precooling and scrubbing stages of the FGD process or blended with the sludge cake at the additive mixing stage of processing.

The sludge stabilization results from two sets of simultaneous reactions that occur when additives are mixed with the dewatered sludge. The first set of reactions occurs over the first 24-72 hr and involves additives and soluble sulfate-sulfite compounds to produce gypsum. The second set of reactions begin immediately after mixing sludge and additives, but continue over a period of several months; these are pozzolanic reactions between the alumina-silica compounds of the flyash and the lime compounds. The second set of reactions is impeded, but not impaired, by temperatures below 40°F. The water content of the mixture has a significant effect on the reactions and must be no more than 40% (6).

The physical and chemical properties of the final product can be controlled by adjusting the additive amount, water content of sludge, and sludge composition. IUCS reports that material suitable for landfill disposal is produced from the sludge if it is dewatered to 60% solids and lime is added to the sludge (flyash is in the dewatered sludge) such that the amount is 4% by wt of dry sludge solids (7).

The final product is reported by IUCS to be a claylike material that can be easily handled, hauled, placed, and compacted. The landfill is structurally suitable for future reclamation. Surface and ground water in the area of the landfill is monitored to determine if contamination by leachate occurs.

The IUCS Poz-O-Tec process is based on another IUCS process that has been successfully used for 20 yr to produce a construction material from flyash, lime, and aggregate (Poz-O-Pac process). Several utilities are now using the Poz-O-Tec process in full-scale FGD sludge treatment and disposal systems (8).

Chemfix

Chemfix offers a process that yields a treated, stabilized sludge that can be handled, hauled, and placed for landfill disposal. This proprietary process uses a two-part inorganic chemical system which reacts with all polyvalent metal ions and sludge components. The slurry from the scrubber is dewatered to form a 60% solids material. The cake is then mixed with additives (sodium silicate and Portland cement) to begin the fixation reactions.

Three classes of reactions are responsible for fixation of the sludge. The first is between soluble silicates and polyvalent metal ions. The second reactions occur between the soluble silicate and the reactive components of the Portland cement. The third reactions are between the Portland cement and the sludge components.

The extent of each of these reactions influences the characteristics of the final product. For the sludge in this study, the material produced is a chemically and physically stable material suitable for landfill disposal. Sodium silicate is added such that the amount is 2% by wt of dry sludge solids and Portland cement, 7%. These rates can be varied to yield desirable product characteristics.

Chemfix has been successfully applying this technology to sludges produced by metal finishing, automotive assembly, sewage treatment, and electronics operations. The technology for FGD sludge stabilization has been applied on the demonstration scale (9).

DESIGN AND ECONOMIC PREMISES

A comparative economic evaluation of several sludge disposal process systems requires that the basis for all processes be for a specific set of design and economic premises. These design and economic premises which encompass the power plant, scrubber system, and sludge disposal system are summarized in the following paragraphs.

Base Case

A base case was established for the power plant, FGD system, and four sludge disposal alternatives. A listing of the base case power plant premises is as follows:

1. New plant with 30-yr life.
2. Single, 500-MW, coal-fired unit.
3. Total operating life of 127,500 hr with average annual capacity of 4,250 hr.
4. Power unit input heat requirement of 9,000 Btu/kWh.
5. Coal heating value of 10,500 Btu/lb.
6. Coal analysis (wt %): 3.5% sulfur (S), dry; 16.0% ash.

The following is a list of FGD system base case premises:

1. Limestone scrubbing process with 1.5 stoichiometry based on SO_2 removed.
2. SO_2 removed to meet New Source Performance Standards (NSPS).
3. Eighty percent of the ash present in the coal is emitted as flyash.
4. Ninety-five percent of the S in the coal is emitted as SO_2.
5. Fifteen percent of the SO_2 removed is converted to gypsum.

6. Flyash and SO_2 are removed simultaneously in the scrubber system.
7. Effluent from the FGD system is 15% solids.

The following is a listing of base case premises for the four disposal alternatives.

Untreated

1. Pump 15% solids to a clay-lined disposal pond.
2. Pond located 1 mi from scrubber facilities.
3. Sludge settles in pond to 50% solids and excess water is recycled to the scrubber system.

Dravo

1. Thickened sludge (35% solids) is treated with Dravo additives: Calcilox (7% of dry sludge) and Thiosorbic lime (1% of dry solids).
2. A gravity thickener is used for dewatering the sludge.
3. Treated sludge is pumped to a clay-lined pond located 1 mi from the scrubber facilities.
4. The ponded sludge settles in the pond to 50% solids and excess water is recycled to the scrubber system.
5. The treated, settled sludge fixes as a soillike material in the pond.

IUCS

1. Effluent from the scrubber system is dewatered (60% solids) using a thickener and rotary drum filter.
2. The dewatered sludge is fixed by mixing with lime (4% of dry sludge).
3. Trucks are used to transport the treated sludge to the landfill disposal site located 1 mi from the scrubber facilities.
4. The treated material is assumed to have claylike properties and can be placed and compacted in the landfill using earthmoving equipment.

Chemfix

1. Effluent from the scrubber system is dewatered (60% solids) using a thickener and rotary drum filter.
2. Dewatered sludge is fixed by mixing with Chemfix additives: Portland cement (7% of dry solids) and sodium silicate (2% of dry solids).
3. Thickened sludge (35% solids) is pumped 1 mi to the disposal site where it is filtered to remove additional water and mixed with additives.
4. The treated material is then hauled to the landfill, placed and compacted using typical earthmoving equipment.

Design Premises

Design premises are the same for all alternatives, making the basis for comparison equal. The following is a summary of these assumptions.

1. Three plant sizes are considered--200, 500 (the base case), and 1500 MW. The 1500-MW plant is assumed to be three 500-MW units.

2. S in coal is 3.5% for the base case. Two alternative cases include 2.0 and 5.0% S.

3. The base case ash content of the coal is 16%. Case variations for 12 and 20% ash are also evaluated for each alternative.

4. Case variations are considered for existing 5-, 10-, and 15-yr-old plants. All other cases are for new plants with a 30-yr operating life and a total operating time of 127,500 hr.

5. Flyash is removed simultaneously with SO_2 in the scrubber system. Case variations are estimated for systems with separate flyash removal facilities--electrostatic precipitator (ESP).

6. Limestone systems are operated at a stoichiometry of 1.5 mol CaO: 1 mol SO_2 removed and lime systems at a stoichiometry of 1.1 mol CaO:1 mol SO_2 removed.

7. Scrubber system spent slurry is assumed to contain 15% by wt solids from the limestone systems and 10% by wt from the lime systems.

8. Sludge is assumed to be primarily calcium sulfite hemihydrate with 15% of the total SO_2 removed being oxidized to gypsum.

9. All raw materials used in the three proprietary processes for fixation are received by rail or truck transportation. Storage facilities are for 30-day capacity and feed bins, intermediate storage tanks, etc., are 8-hr capacity.

Economic Premises

A midwestern plant location was selected. Raw materials are readily available and a large amount of coal-fired generating capacity exists in this region. Land costs are assumed $3500/acre. Economic assumptions are summarized as follows (10):

1. All cost estimates are based on Chemical Engineering cost indices (labor index - 237.9, material index - 264.9). Capital costs are projected to mid-1979 and revenue requirements are for mid-1980. The project is assumed to start in mid-1977 and be completed in mid-1980. The midpoint for construction costs is mid-1979; startup, mid-1980.

2. Direct capital costs cover process equipment, piping and insulation, transport lines, foundations and structural, excavation site preparation, roads and railroads, electrical, instrumentation, buildings, pond construction, and earthmoving equipment. Material and labor (fabrication and installation) costs for each of these items were estimated. These estimates are based on costs obtained from vendors (equipment companies, contractors, etc.) and related literature information.

3. Indirect capital costs include engineering design and supervision, architect and engineering contractor expenses, construction expenses, contractor fees, contingency, allowance for startup and modifications, and interest during construction. Two other capital cost items not included as indirect costs, but in the total capital requirements, are working capital and land. These estimates are based on current industry practice and authoritative literature sources.

4. Direct costs for revenue requirements include raw materials, labor, and electricity and are projected to mid-1980. Other direct costs are operating expenses for earthmoving equipment. These costs were also based on authoritative literature sources and current market prices obtained from vendors and utility companies.

5. Indirect costs for revenue requirements are capital charges and overheads.

6. Capital charges are based on regulated utility economics.

7. Revenue requirements are projected for an annual 7000-hr operation. Other estimates for lifetime revenue requirements are based on the declining operating time for the plant. Also estimates are made for constant annual operating loads (7000 and 5000 hr) throughout the life of the plant.

8. The revenue requirement estimates of systems with landfill disposal include a cost for land preparation. This annual cost is based on the annual quantity of land used for the landfill. A unit cost of $1700/acre is used which covers the preparation of land before disposal and the recovery of the land following disposal. These costs include excavation and return of topsoil, landscaping to minimize seepage, and diversion of runoff from the disposal site.

RESULTS

A base case was established for each of the four primary disposal alternatives. A material balance, flow diagram, equipment description list, instrumentation diagram, and overall plant layout drawing for each system were prepared. This information was used to make an estimate of the total capital investment for each system. Case variations were estimated for each of the four primary alternatives resulting in a total of 121 estimates.

These case variations included power plant size, remaining plant life, coal analysis, distance from scrubbing facility to disposal area, transportation mode, sludge composition, and fixation additive rates.

Tables S-1 and S-2 are summaries of the total capital and annual revenue requirements for the 121 estimates. Appendix A includes a detailed tabulation of costs for each of the estimates (capital and annual revenue requirements).

Total Capital Investment and Annual Revenue Requirements

The relative ranking of the total capital investments for the four base case disposal alternatives is as follows:

	Total capital investment, M$	$/kW
IUCS stabilization	10,717	21.4
Chemfix stabilization	13,531	27.1
Untreated ponding	17,211	34.4
Dravo stabilization	24,114	48.2

The IUCS and Chemfix base case processes are similar and therefore the difference between the capital investment is relatively small (compared to the Dravo and untreated alternatives). Chemfix's capital investment is greater than IUCS primarily because of the difference in the method of transporting the material to the disposal site (pumping vs truck). The capital investments for these two processes is significantly lower than for the Dravo and untreated alternatives because of the pond construction costs for Dravo and untreated. Pond construction costs are very large and represent a large portion of the total capital investments for the untreated and Dravo processes. The Dravo process requires a greater capital investment than the untreated process because of the costs of dewatering, handling, additive storage, and treatment equipment needed for the Dravo system.

The unit revenue requirements for the four base case estimates are as follows:

	$/ton (dry solids)	Mills/kWh
Untreated	8.08	0.94
IUCS	12.55	1.51
Dravo	15.32	1.91
Chemfix	16.51	2.00

Revenue requirements are lowest for the untreated alternative because, (1) there are no raw materials (fixation additives) required, and (2) labor costs for operation and maintenance are low because of the relative simplicity of the process. The IUCS process is similar to the Chemfix process, but raw material costs are much greater, and therefore the revenue requirements are much greater for Chemfix. Both Chemfix and IUCS require earthmoving equipment for transport, placement, and compaction of treated sludge in a landfill.

TABLE S-1. SUMMARY OF TOTAL CAPITAL INVESTMENT[a] - ALL PROCESSES

Case	Untreated		Dravo		IUCS		Chemfix	
	k$	$/kW	k$	$/kW	k$	$/kW	k$	$/kW
Base case[b]	17,211[c]	34.4[c]	24,114[d]	48.2[d]	10,717[e]	21.4[e]	13,531[f]	27.1[f]
Variation from base case								
200 MW new	9,800	49.0	13,942	69.7	7,193	36.0	9,259	46.3
200 MW existing, 25-yr remaining life	8,480	42.4	13,258	66.3	7,428	37.1	9,448	47.2
200 MW existing, 20-yr remaining life	6,844	34.2	11,597	58.0	7,351	36.8	9,367	46.8
200 MW existing, 15-yr remaining life	5,511	27.6	10,239	51.2	7,295	36.5	9,311	46.5
Existing, 25-yr remaining life	14,578	29.2	21,416	42.8	10,591	21.2	13,400	26.8
Existing, 20-yr remaining life	11,399	22.8	18,281	36.6	10,402	20.8	13,204	26.4
Existing, 15-yr remaining life	8,822	17.6	15,553	31.1	10,269	20.5	13,077	26.2
1500 MW new	36,455	24.3	48,235	32.2	20,105	13.4	24,104	16.1
1500 MW existing, 25-yr remaining life	30,212	20.1	41,382	27.6	19,952	13.3	23,922	15.9
1500 MW existing, 20-yr remaining life	22,904	15.3	33,924	22.6	19,382	12.9	23,337	15.6
1500 MW existing, 15-yr remaining life	16,999	11.3	27,905	18.6	18,976	12.7	22,915	15.3
12% ash in coal	15,031	30.1	21,446	42.9	9,345	18.7	11,879	23.8
20% ash in coal	19,055	38.1	26,028	52.1	11,957	23.9	14,192	28.4
2% S in coal	13,390	26.8	19,251	38.5	9,025	18.1	11,123	22.2
5% S in coal	20,655	41.3	28,523	57.0	12,283	24.6	14,854	29.7
200 MW, no flyash	6,716	33.6	12,242	61.2	7,301	36.5	7,767	38.8
No flyash	11,397	22.8	19,745	39.5	9,839	19.7	10,124	20.2
1500 MW, no flyash	23,595	15.7	38,722	25.8	18,103	12.1	18,313	12.2
5 mi to disposal	26,836	53.7	30,994	62.0	11,377	22.8	20,227	40.5
10 mi to disposal	37,420	74.8	37,765	75.5	11,891	23.8	26,988	54.0
Fixation additive amount - variation 1	-	-	23,120	46.2	10,302	20.6	16,270	32.5
Fixation additive amount - variation 2	-	-	25,209	50.4	10,748	21.5	14,757	29.5
Lime scrubbing process	16,226	32.5	21,318	42.6	10,383	20.8	12,431	24.9
Intermediate ponding and truck to landfill	-	-	12,670	25.3	-	-	-	-
Transport by truck to disposal area	-	-	-	-	-	-	11,740	23.5
Clarify (35% solids) and pump 1 mi	18,490	37.0	-	-	-	-	-	-
Clarify (35% solids) and pump 5 mi	24,881	49.8	-	-	-	-	-	-
Clarify (35% solids) and pump 10 mi	31,458	62.9	-	-	-	-	-	-
Clarify, filter (60% solids) and truck 1 mi	8,294	16.6	-	-	-	-	-	-
Clarify, filter (60% solids) and truck 5 mi	8,825	17.7	-	-	-	-	-	-
Clarify, filter (60% solids) and truck 10 mi	9,249	18.5	-	-	-	-	-	-
200 MW, constrained pond acreage (50% of optimum)	12,774	63.9	20,701	103.5	-	-	-	-
200 MW, constrained pond acreage (75% of optimum)	10,203	51.0	17,305	86.5	-	-	-	-
Constrained pond acreage (50% of optimum)	22,676	45.4	37,697	75.4	-	-	-	-
Constrained pond acreage (75% of optimum)	17,985	36.0	31,061	62.1	-	-	-	-
1500 MW, constrained pond acreage (50% of optimum)	48,917	32.6	80,098	53.4	-	-	-	-
1500 MW, constrained pond acreage (75% of optimum)	38,228	25.5	64,503	43.0	-	-	-	-
Pond settled density (40% solids)	20,070	40.1	-	-	-	-	-	-
Pond settled density (60% solids)	15,194	30.4	-	-	-	-	-	-
Unlined pond	14,391	28.8	-	-	-	-	-	-
Synthetic pond lining ($1.50/yd^2)	20,994	42.0	-	-	-	-	-	-
Synthetic pond lining ($2.50/yd^2)	23,070	46.1	-	-	-	-	-	-
Synthetic pond lining ($3.50/yd^2)	24,959	49.9	-	-	-	-	-	-
Synthetic pond lining ($4.50/yd^2)	26,707	53.4	-	-	-	-	-	-

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a. Basis: Midwest plant location, mid-1979 costs; SO_2 and flyash removed together to meet NSPS.

b. New 500-MW plant; 30-yr life; coal analysis (by wt): 3.5% S (dry basis), 16% ash; flyash and SO_2 removed together to meet NSPS, limestone process with 1.5 stoichiometry based on SO_2 removed.

c. Direct ponding of 15% slurry clay-lined pond; 1 mi from scrubber facilities; 50% solids settled density.

d. Ponding of 35% solids slurry; clay-lined pond; pump 1 mi to pond from scrubber facilities; 50% solids settled density in pond; treated with Calcilox (7% of dry sludge) and Thiosorbic lime (1% of dry sludge).

e. Landfill disposal of 60% solids material; 1 mi to landfill from scrubber facilities; trucks used for transport of treated sludge; treated with lime (4% of dry sludge).

f. Landfill disposal of 60% solids material; 1 mi to landfill from scrubber facilities; pipeline used for transport of thickener underflow to disposal and treatment area, treated with Portland cement (7% of dry sludge) and sodium silicate (2% of dry sludge).

TABLE S-2. SUMMARY OF TOTAL ANNUAL REVENUE REQUIREMENTS[a] - ALL PROCESSES

Case	Untreated		Dravo		IUCS		Chemfix	
	Annual amount, k$	Mills/ kWh	Annual amount, k$	Mills/ kWh	Annual amount, k$	Mills/ kWh	Annual amount, k$	Mills/ kWh
Base case[b]	3,280[c]	0.94[c]	6,701[d]	1.91[d]	5,291[e]	1.51[e]	6,988[f]	2.00[f]
Variation from base case								
200 MW new	2,014	1.44	3,643	2.60	3,567	2.55	4,529	3.24
200 MW existing, 25-yr remaining life	1,841	1.32	3,672	2.62	3,699	2.64	4,695	3.35
200 MW existing, 20-yr remaining life	1,605	1.15	3,461	2.47	3,725	2.66	4,730	3.38
200 MW existing, 15-yr remaining life	1,433	1.02	3,390	2.42	3,822	2.73	4,856	3.47
Existing, 25-yr remaining life	2,906	0.83	6,377	1.82	5,402	1.54	7,152	2.04
Existing, 20-yr remaining life	2,135	0.70	5,941	1.70	5,430	1.55	7,191	2.05
Existing, 15-yr remaining life	2,130	0.61	5,728	1.64	5,559	1.59	7,359	2.10
1500 MW new	6,746	0.64	14,264	1.36	10,411	0.99	14,362	1.37
1500 MW existing, 25-yr remaining life	5,827	0.55	13,821	1.32	10,656	1.01	14,749	1.40
1500 MW existing, 20-yr remaining life	4,726	0.45	12,749	1.21	10,684	1.02	14,791	1.41
1500 MW existing, 15-yr remaining life	3,969	0.38	12,138	1.16	10,900	1.04	15,053	1.43
12% ash in coal	2,902	0.83	5,924	1.69	4,533	1.30	6,229	1.78
20% ash in coal	3,609	1.03	7,406	2.12	5,971	1.71	7,600	2.17
2% S in coal	2,639	0.75	5,314	1.52	4,654	1.33	5,935	1.70
5% S in coal	3,869	1.10	8,007	2.29	6,188	1.77	8,263	2.36
200 MW, no flyash	1,495	1.07	3,063	2.19	3,396	2.43	3,766	2.69
No flyash	2,289	0.65	5,073	1.45	4,650	1.33	5,184	1.48
1500 MW, no flyash	4,546	0.43	10,448	1.00	8,162	0.78	9,771	0.93
5 mi to disposal	5,527	1.58	8,124	2.32	6,490	1.85	8,675	2.48
10 mi to disposal	7,504	2.14	9,360	2.67	7,475	2.14	10,003	2.86
Fixation additive rate - variation 1	-	-	6,052	1.73	4,994	1.43	13,651	3.90
Fixation additive rate - variation 2	-	-	7,577	2.16	5,511	1.57	10,099	2.89
Lime scrubbing process	3,136	0.90	6,168	1.76	5,093	1.46	6,200	1.77
Intermediate ponding and truck to landfill	-	-	6,620	1.89	-	-	-	-
Transport by truck to disposal area	-	-	-	-	-	-	6,698	1.91
Clarify (35% solids) and pump 1 mi	3,694	1.06	-	-	-	-	-	-
Clarify (35% solids) and pump 5 mi	5,195	1.48	-	-	-	-	-	-
Clarify (35% solids) and pump 10 mi	6,450	1.84	-	-	-	-	-	-
Clarify, filter (60% solids) and truck 1 mi	3,809	1.09	-	-	-	-	-	-
Clarify, filter (60% solids) and truck 5 mi	4,925	1.41	-	-	-	-	-	-
Clarify, filter (60% solids) and truck 10 mi	5,818	1.66	-	-	-	-	-	-
200 MW, constrained pond acreage (50% of optimum)	2,462	1.76	4,423	3.16	-	-	-	-
200 MW, constrained pond acreage (75% of optimum)	2,033	1.45	4,134	2.95	-	-	-	-
Constrained pond acreage (50% of optimum)	4,119	1.18	9,109	2.60	-	-	-	-
Constrained pond acreage (75% of optimum)	3,365	0.96	7,901	2.25	-	-	-	-
1500 MW, constrained pond acreage (50% of optimum)	8,985	0.86	20,366	1.94	-	-	-	-
1500 MW, constrained pond acreage (75% of optimum)	7,037	0.67	17,290	1.65	-	-	-	-
Pond settled density (40% solids)	3,747	1.07	-	-	-	-	-	-
Pond settled density (60% solids)	2,949	0.84	-	-	-	-	-	-
Unlined pond	2,765	0.79	-	-	-	-	-	-
Synthetic pond lining ($1.50/yd^2)	3,882	1.11	-	-	-	-	-	-
Synthetic pond lining ($2.50/yd^2)	4,253	1.21	-	-	-	-	-	-
Synthetic pond lining ($3.50/yd^2)	4,590	1.31	-	-	-	-	-	-
Synthetic pond lining ($4.50/yd^2)	4,900	1.40	-	-	-	-	-	-

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a. Basis: Midwest plant location; mid-1980 operating costs; 7,000 hr/yr on-stream time.

b. New 500-MW plant; 30-yr life; coal analysis (by wt): 3.5% S (dry basis), 16% ash; flyash and SO_2 removed together to meet NSPS, limestone process with 1.5 stoichiometry based on SO_2 removed.

c. Direct ponding of 15% slurry; clay-lined pond; 1 mi from scrubber facilities; 50% solids settled density.

d. Ponding of 35% solids slurry; clay-lined pond; pump 1 mi to pond from scrubber facilities; 50% solids settled density in pond; treated with Calcilox (7% of dry sludge) and Thiosorbic lime (1% of dry sludge).

e. Landfill disposal of 60% solids material; 1 mi to landfill from scrubber facilities, trucks used for transport of treated sludge; treated with lime (4% of dry sludge).

f. Landfill disposal of 60% solids material; 1 mi to landfill from scrubber facilities; pipeline used for transport of thickener underflow to disposal and treatment area, treated with Portland cement (7% of dry sludge) and sodium silicate (2% of dry sludge).

This equipment requires more operators, maintenance, and must be replaced more often than most chemical process equipment (6 yr vs 20 yr)and therefore their use causes an increase in annual revenue requirements. The annual charges for equipment depreciation and the annual cost of capital greatly increase the revenue requirements for the Dravo process. Dravo process additive costs are much more than the IUCS additive costs. Additive costs are greatest for the Chemfix process.

These rankings are for base case systems which are for new 500-MW plants burning coal with 3.5% S and 16% ash. The relative position of the four alternatives changes for some of the case variations. The unit revenue requirements for all case variations are included in the section Economic Evaluation and Comparison.

The total capital investments and annual revenue requirements for the three plant sizes considered in this study are as follows:

Process	Capital investment, k$		
	200 MW	500 MW (base)	1,500 MW
Untreated	9,800	17,211	36,455
Dravo	13,942	24,114	48,235
IUCS	7,193	10,717	20,105
Chemfix	9,259	13,531	24,104

Process	Total annual revenue requirements, k$		
	200 MW	500 MW (base)	1,500 MW
Untreated	2,014	3,280	6,746
Dravo	3,643	6,701	14,264
IUCS	3,567	5,291	10,411
Chemfix	4,529	6,988	14,362

Another factor significantly affecting costs is the distance to the disposal site. The following is a summary of costs for the disposal site distance variations considered in this study. All estimates are for a new 500-MW (base case) plant.

Process	Capital investment, k$		
	1 mi (base)	5 mi	10 mi
Untreated	17,211	26,836	37,420
Dravo	24,114	30,994	37,765
IUCS	10,717	11,377	11,891
Chemfix	13,531	20,227	26,988

Process	Total annual revenue requirement, k$		
	1 mi (base)	5 mi	10 mi
Untreated	3,280	5,527	7,504
Dravo	6,701	8,124	9,360
IUCS	5,291	6,490	7,475
Chemfix	6,988	8,675	10,003

The quantity of land available for construction of disposal ponds can be a significant factor for many plant sites in selecting a disposal alternative. Several cost estimates were made to evaluate the effect of land availability on total capital investments and annual revenue requirements. In every ponding case considered in this study (except these particular variations described here), the pond construction cost was minimized by optimizing between pond construction and land costs. The following estimates show the effect of limiting the pond acreage to 50 and 75% of the optimum acreage for an untreated system.

Plant size	Capital investment, k$		
	Optimum land	75% optimum	50% optimum
200 MW	9,800	10,203	12,774
500 MW	17,211	17,985	22,676
1500 MW	36,455	38,228	48,917

Plant size	Total annual revenue requirements, k$		
	Optimum land	75% optimum	50% optimum
200 MW	2,014	2,033	2,462
500 MW	3,280	3,365	4,119
1500 MW	6,746	7,037	8,985

Lifetime Revenue Requirements

Lifetime revenue requirements were calculated for three cases (200-, 500-, and 1500-MW new plants) of each disposal alternative. Table S-3 presents a summary of the cumulative discounted process costs and equivalent levelized unit increase in revenue requirements over the life of the power plant for the four disposal alternatives. Lifetime levelized unit revenue requirements are slightly higher than corresponding annual unit revenue requirements due to the declining operating profile of the power plant. The average annual on-stream time over the life of the plant is 4250 hr; however, the annual revenue requirement estimates are based on 7000 hr of operating time (first year).

TABLE S-3. SUMMARY OF LIFETIME REVENUE REQUIREMENTS (ALL PROCESSES) - ACTUAL AND DISCOUNTED CUMULATIVE TOTAL AND UNIT (MILLS/KWH) REVENUE REQUIREMENTS OVER THE 30-YR LIFE OF THE POWER PLANT[a]

Case[b]	Total actual lifetime revenue requirement, $	Lifetime average unit revenue requirements, mills/kWh	Total present worth lifetime revenue requirement, $[c]	Levelized unit revenue requirements,[d] mills/kWh
Untreated				
200 MW	58,750,000	2.30	20,204,800	2.03
500 MW	97,757,800	1.53	33,612,100	1.35
1500 MW	203,309,200	1.06	69,819,400	0.94
Dravo				
200 MW	94,392,200	3.70	33,368,200	3.36
500 MW	175,764,900	2.76	62,052,600	2.50
1500 MW	375,002,700	1.96	133,456,200	1.79
IUCS				
200 MW	89,013,000	3.49	30,584,100	3.08
500 MW	131,224,200	2.06	45,381,700	1.83
1500 MW	254,498,000	1.33	88,798,600	1.19
Chemfix				
200 MW	111,241,300	3.36	38,655,100	3.89
500 MW	167,942,300	2.63	59,099,300	2.38
1500 MW	333,190,900	1.74	119,154,500	1.60

a. Basis
Over previously defined power plant operating profile. 30-yr life: 7,000 hr for first 10 yr; 5,000 hr for next 5 yr; 3,500 hr for next 5 yr; 1,500 hr for next 10 yr.
Midwest plant location, 1980 operating costs.
Constant labor cost assumed over life of project.

b. New plants, coal analysis (wt %): 3.5% S (dry), 16% ash, flyash removed with SO_2 to meet NSPS.

c. Discounted at 10% to initial year.

d. Equivalent to discounted process cost over life of power plant.

Constant Operating Load - Cost Requirements

To evaluate the effect of a constant annual operating load over a plant's life, estimates were made for disposal systems (each of the four alternatives) to use on 200-, 500-, and 1500-MW plants. Estimates for these 12 cases were made for both 5000 and 7000 hr/yr operation over the 30-yr system life. Tables S-4 and S-5 are summaries of these estimates. Both total capital investment and annual revenue requirements are increased over the corresponding values for systems with the declining operating profile.

Land Requirements

The cost of land represents a significant portion of the total investment required for a sludge disposal system. The cost of land was estimated to be \$3500/acre. A computer program developed by TVA to estimate the cost of a disposal pond was used. The program determines the optimum pond acreage based on land and pond construction costs. Land requirements for the four base case alternatives are as follows:

Process	Acre	Percent of total capital investment
Untreated	407	8.3
Dravo	414	6.0
IUCS	193	6.3
Chemfix	198	5.1

Land requirements for the case variations evaluated in this study varied from 21 to 1454 acres. The variations in land requirements are a result of the type of disposal process used. For the Dravo and untreated alternatives, ponding is used and land requirements are in excess of 400 acres (base cases). These requirements are a function of pond depth (average of 21 ft total depth and 3.0 ft excavation depth) and the quantity (50% solids) of material for disposal. A landfill is used for disposal of treated material from the Chemfix and IUCS process. The average landfill depth is 30 ft and the material for disposal is about 60% solids. Land requirements are less than 200 acres for these two processes (base cases).

CONCLUSIONS AND RECOMMENDATIONS

Two categories of conclusions are discussed. The first is concerned with the economic comparisons of disposal process alternatives. The second category pertains to the effects of case variations for each of the disposal process alternatives.

Economic Comparison of Alternatives

The initial comparison between alternatives that should be made is between the base case systems for the four alternatives. The IUCS process

TABLE S-4. SUMMARY OF LIFETIME REVENUE REQUIREMENTS FOR SYSTEMS OPERATING AT CONSTANT LOAD OF 7,000 HR/YR DURING 30-YR LIFE - ACTUAL AND DISCOUNTED CUMULATIVE TOTAL AND UNIT REVENUE REQUIREMENTS OVER THE LIFE OF THE PLANT[a]

Case[b]	Total actual lifetime revenue requirement, $	Lifetime average unit revenue requirements, mills/kWh	Total present worth lifetime revenue requirement, $[c]	Levelized unit revenue requirements,[d] mills/kWh
Untreated				
200 MW	80,584,600	1.92	26,228,200	2.26
500 MW	137,899,200	1.31	45,197,300	1.56
1500 MW	293,677,800	0.93	96,399,600	1.11
Dravo				
200 MW	129,537,700	3.08	41,066,500	3.53
500 MW	243,352,900	2.32	76,570,300	2.64
1500 MW	538,992,900	1.71	167,889,600	1.93
IUCS				
200 MW	111,398,500	2.65	33,019,700	2.84
500 MW	167,635,400	1.60	49,563,800	1.80
1500 MW	335,937,400	1.07	98,617,900	1.25
Chemfix				
200 MW	140,934,100	3.36	41,840,600	3.60
500 MW	219,892,700	2.09	64,816,200	2.23
1500 MW	457,926,200	1.45	133,464,500	1.53

a. Basis
Midwest plant location, 1980 operating cost.
30-yr life at 7,000 hr/yr, 210,000 hr total operating time.

b. New plants, coal analysis (wt %): 3.5% S (dry), 16% ash, flyash removed with SO_2 to meet NSPS.

c. Discounted at 10% to initial year.

d. Equivalent to discounted process cost over life of power plant.

TABLE S-5. SUMMARY OF LIFETIME REVENUE REQUIREMENTS FOR SYSTEMS OPERATING AT CONSTANT LOAD OF 5,000 HR/YR DURING 30-YR LIFE - ACTUAL AND DISCOUNTED CUMULATIVE TOTAL AND UNIT REVENUE REQUIREMENTS OVER THE LIFE OF THE PLANT[a]

Case[b]	Total actual lifetime revenue requirement, $	Lifetime average unit revenue requirements, mills/kWh	Total present worth lifetime revenue requirement, $[c]	Levelized unit revenue requirements,[d] mills/kWh
Untreated				
200 MW	68,635,900	2.29	22,269,300	2.68
500 MW	113,972,700	1.52	37,296,900	1.80
1500 MW	238,074,400	1.06	78,056,500	1.25
Dravo				
200 MW	111,652,500	3.72	35,498,100	4.28
500 MW	202,043,900	2.69	63,826,800	3.08
1500 MW	432,232,700	1.92	135,328,300	2.17
IUCS				
200 MW	105,897,500	3.53	31,497,700	3.79
500 MW	154,682,700	2.06	45,980,100	2.22
1500 MW	297,631,200	1.32	88,019,300	1.41
Chemfix				
200 MW	135,579,800	4.52	40,359,100	4.86
500 MW	194,309,700	2.59	57,798,000	2.79
1500 MW	382,117,300	1.70	112,489,900	1.81

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a. Basis
   Midwest plant location, 1980 operating cost.
   30-yr life at 5,000 hr/yr, 150,000 hr total operating time.

b. New plants, coal analysis (wt %): 3.5% S (dry), 16% ash, flyash removed with SO_2 to meet NSPS.

c. Discounted at 10% to initial year.

d. Equivalent to discounted process cost over life of power plant.

requires the lowest total capital investment of the four processes and the Dravo process requires the highest. The total annual revenue requirement is least for the untreated ponding base case and is highest for the Chemfix system.

As comparisons between the four alternatives are made for the case variations (plant size, age, etc.), the relative ranking of costs sometimes changes. These results can be seen in Tables 1 and 2 . As the remaining life of the power plant is reduced, the untreated ponding alternatives become the least costly (capital investment) alternative. This decrease in capital investment is due to the large reduction in the pond construction costs for the older plants, while the reduction in costs for the IUCS landfill system is only slightly reduced as the remaining plant life is reduced.

The relative ranking of the capital investments is unchanged for the case variations involving a change in power plant size, coal analysis, and distance to the disposal site.

As comparisons between the revenue requirements are made for the case variations, the relative ranking of the costs seldom changes from that of the base cases. One set of cases that does change is the 200-MW plants. The Dravo alternative is ranked second behind untreated ponding in these cases. This reflects the effect of the smaller depreciation charges for the smaller plants (due to smaller capital investment for pond construction).

Effect of Case Variations for Each Alternative

Table S-6 shows the degree of change from the base case of capital investments and revenue requirements for the case variations of the four alternatives. The following is a discussion of major variations.

Plant size -- In every case because of economies of scale this factor resulted in a large change from the base case capital investment and revenue requirements.

Remaining plant life -- The effect of this variable on costs depends on the particulate process and plant size. In general, the alternatives with disposal ponds (untreated and Dravo) were more sensitive to changes in remaining plant life. This sensitivity is due to the effect of pond size and cost on the total costs for the systems.

Coal composition -- This variation involved only a small change in the quantity of material and therefore resulted in small to moderate (± 40%) changes in costs.

Distance to disposal -- Both total capital investments and annual revenue requirements were significantly changed from the base case as the distance to the disposal site was increased. Only for the IUCS system was the increase in capital investment rated as small (from ± 10% to ± 20% change from the base case). This increase resulted from the small change in

TABLE S-6. EFFECT OF TOTAL CAPITAL INVESTMENT AND ANNUAL REVENUE REQUIREMENT BY CASE VARIATIONS FOR ALL PROCESSES

	Degree of change from base case[a]							
	Capital investment				Revenue requirements			
Case variations	Untreated	Dravo	IUCS	Chemfix	Untreated	Dravo	IUCS	Chemfix
Plant size	Large	Large	Large	Large	Large	Large	Large	Large
Remaining plant life	Large	Moderate	Slight	Slight	Moderate	Small	Slight	Slight
Ash in coal	Small	Small	Small	Small	Small	Small	Small	Small
S in coal	Moderate	Small	Small	Small	Small	Moderate	Small	Small
No flyash in sludge	Moderate	Small	Slight	Moderate	Moderate	Moderate	Small	Moderate
Distance to disposal	Large	Large	Small	Large	Large	Large	Large	Large
Fixation additive rate	-	Slight	Slight	Small	-	Small	Slight	Large
Limestone vs lime scrubbing process	Slight	Small	Slight	Slight	Slight	Slight	Slight	Small
Thickened sludge	Small	-	-	-	Small	-	-	-
Thickened sludge and distance to disposal site	Large	-	-	-	Large	-	-	-
Filtered sludge	Large	-	-	-	Small	-	-	-
Filtered sludge and distance to disposal site	Large	-	-	-	Large	-	-	-
Constraint of available pond acreage	Moderate	Large	-	-	Moderate	Large	-	-
Pond lining	Large	-	-	-	Large	-	-	-
Truck to disposal	-	-	-	Small	-	-	-	Slight
Intermediate ponding and truck to landfill	-	Large	-	-	-	Slight	-	-
Settled density in pond	Small	-	-	-	Small	-	-	-

a. An arbitrary scale is established with the following rating criteria being applied.

Slight: <±10% change from the base case
Small: from ±10% to ±20%
Moderate: from >±20% to ±40%
Large: >±40%

costs for truck transporting of sludge to the disposal area. All other processes use pipelines for sludge transport.

Fixation additive rate -- This variation applies only to the treatment processes. All costs, except the revenue requirement of the Chemfix system, had only a slight to small change for this variation.

Sludge solids -- One variation of the base case untreated process was the amount of dewatering (thickening, filtration) used before the sludge was transported to the disposal area. Costs were slightly changed (increased) if the slurry was thickened (35% solids) before pumping to the pond. A large reduction in costs was found for capital investment of systems where the sludge was filtered (60% solids), trucked, and placed in a landfill for disposal.

Pond acreage -- Changes were from moderate to large for this case variation and resulted from increased pond construction costs. These cases were considered to evaluate the effects of the available pond acreage (constrained) on costs.

Pond lining -- A large change (increase) in costs is experienced if synthetic pond linings are used instead of typical clay linings (base case).

Chemfix - truck transport -- The base case for the Chemfix process was for the pipeline transport of partially dewatered sludge to the disposal site where it was dewatered further and chemically treated before placement in a landfill. One case variation was included to evaluate the effect of the transportation mode on costs (truck transport vs pipeline transport). Only a small change (10-20% increase) in capital costs was found and revenue requirements were slightly increased (<1%).

Dravo - landfill disposal -- One case variation to evaluate the Dravo landfill process was included. This Dravo system involves intermediate ponding, truck transport, and landfill disposal of Dravo treated sludge. The capital investment for this system was much less than that of the base case ($24,114,000 vs $12,670,000). This change is due primarily to the absence of larger pond construction costs. Revenue requirements were only slightly changed.

Pond settled density -- A small (± 10% to ± 20%) change in costs was experienced as the settled density in the disposal pond was varied.

RECOMMENDATIONS

The state of technology, environmental regulations, and economic factors are expected to be continuously changing for sludge disposal alternatives. In order to provide usable information concerning the economics of FGD sludge disposal, additional evaluations are needed to consider the changing conditions mentioned above. Studies should be initiated to evaluate processes for gypsum disposal, physical stabilization, Dravo landfill process, and mine disposal.

ECONOMICS OF DISPOSAL OF LIME-LIMESTONE SCRUBBING WASTES:

UNTREATED AND CHEMICALLY TREATED WASTES

INTRODUCTION

The promulgation of emission standards for large fossil fuel-fired power stations by the U.S. Environmental Protection Agency (EPA) has created the need for reliable pollution control techniques. Most (over 90%) systems used for flue gas desulfurization (FGD) are based on processes that use lime or limestone as the reactant source. Tables 1 and 2 list the FGD systems either in operation or under construction in the U.S. With each FGD system listing is additional information including the type of system and FGD sludge disposal alternative being used or considered for use. These lime-limestone FGD (wet scrubbing) systems produce calcium-based waste products that present an enormous solid waste handling and disposal problem (11).

A broad range of research, development, and demonstration programs related to the disposal of these FGD wastes are underway. These programs are supported and funded by utilities, research organizations, and government agencies. A significant portion of this effort has been sponsored by EPA. Nineteen different EPA projects have been undertaken to evaluate, develop, demonstrate, and recommend environmentally acceptable cost-effective techniques for disposal and utilization of flue gas cleaning (FGC) wastes. These projects are part of an EPA program titled "Control of Waste and Water Pollution from Combustion Sources" or simply "Waste and Water Program." Projects generally fall into six primary categories: (1) environmental assessment of FGC waste disposal, (2) technology assessment development, (3) disposal economics, (4) alternative disposal methods, and (5) utilization of wastes. Table 3 lists the projects (June 1977) that make up EPA's waste and water program with other pertinent information concerning each project included (11).

This study is in the category of "disposal economics," and involves the conceptual design and economic evaluation of selected waste disposal systems currently being used by the utility industry or marketed for utility use by the process developers. The primary disposal alternatives that are most commonly being used or planned for use by the utility industry are (1) ponding in a lined pond and (2) landfill disposal. The waste material may be subjected to a number of mechanical and chemical processing operations before ultimate disposal. These operations include dewatering and chemical fixation.

Since there are several disposal alternatives available to the utility industry, a few promising processes and disposal methods for a detailed economic evaluation must be selected. The alternatives chosen for this study are grouped into two general categories.

TABLE 1. SUMMARY OF INFORMATION FOR FGD SYSTEMS UNDER CONSTRUCTION IN THE U.S.

Power plant			FGD installation					Fuel				Pollution removal				FGD product	
												Particulate		SO_2			
Utility	Station	Boiler No.	FGD MW	FGD startup	Process	New or retrofit	Total trains	Type	Btu/lb	% S	% ash	Device	%	Device	%	Material	Disposal
South Carolina Public Service	Winyah	2	140	6/77	Limestone scrubbing	N	1	Coal	11,800	1.1	12-13	ESP	99.4	-	69	Unstabilized sludge	Unlined pond
Arizona Public Service	Cholla	2	250	6/77	Limestone	N	4	Coal	10,000	0.44-1.0	-	Venturi scrubber	70	Packed tower		-	-
Utah Power & Light	Huntington	1	415	6/77	Lime scrubbing	N	-	Coal	-	0.5	-	ESP	-	-	-	Stabilized sludge	-
Louisville Gas & Electric	Mill Creek	3	425	7/77	Lime scrubbing	N	-	Coal	11,000	3.5-4.0	-	-	-	Mobile-bed contactor	-	Stabilized sludge	-
Louisville Gas & Electric	Cane Run	5	183	12/77	Lime scrubbing	R	-	Coal	13,000	3.5-4.0	-	-	-	Marble bed	-	-	-
Southern Illinois Power Cooperative	Marion	6	184	1/78	Limestone scrubbing	N	2	Coal	-	-	-	ESP	-	Spray tower	89.4	Unstabilized sludge	-
Springfield City Utilities	Southwest	1	200	8/77	Limestone scrubbing	N	2	Coal	12,500	3.5	12-14	ESP	-	Three-bed TCA	-	Stabilized sludge	-
Minnkota Power Cooperative	Milton R. Young	2	450	8/77	Lime-alkaline flyash scrubbing	N	2	Lignite	6,500	0.7	-	ESP	99.6	-	75	-	-
Indianapolis Power & Light	Petersburg	3	530	9/77	Limestone scrubbing	N	4	Coal	-	3.0-3.5	-	ESP	99.3	TCA	85	Stabilized sludge	-
Pennsylvania Power	Bruce Mansfield	2	835	10/77	Lime scrubbing	N	6	Coal	11,900	3.0-4.5	8-15	Variable-throat venturi scrubber	99.8	Fixed-throat venturi scrubber	92	Stabilized sludge	Unlined pond
Texas Utilities	Martin Lake	1	750	10/77	Limestone scrubbing	N	6	Coal	7,380	1.0	-	ESP	-	-	-	Stabilized sludge	-
Texas Utilities	Martin Lake	2	750	3/78	Limestone scrubbing	N	6	Coal	7,380	1.0	-	ESP	-	-	-	Stabilized sludge	-
Texas Utilities	Monticello	3	750	3/78	Limestone scrubbing	N	3	Lignite	-	1.0	-	ESP	-	-	-	-	-
Public Service Company of New Mexico	San Juan	1	375	11/77	Sodium solution-SO_2 reduction	N	4	Coal	-	0.8	-	ESP, venturi scrubber	99.7	-	-	-	-
Public Service Company of New Mexico	San Juan	2	340	11/77	Sodium solution-SO_2 reduction	R	4	Coal	-	0.8	18	ESP, venturi scrubber	99.7	-	-	-	-
So. Mississippi Electric Power	R. D. Morrow	1	180	11/77	Limestone scrubbing	N	-	Coal	-	1.0	-	ESP	99.6	-	85	Stabilized sludge	-

(continued)

TABLE 1 (continued)

Power plant			FGD installation					Fuel				Pollution removal				FGD product	
												Particulate		SO_2			
Utility	Station	Boiler No.	FGD MW	FGD startup	Process	New or retrofit	Total trains	Type	Btu/lb	% S	% ash	Device	%	Device	%	Material	Disposal
So. Mississippi Electric Power	R. D. Morrow	2	180	6/78	Limestone scrubbing	N	-	Coal	-	1.0	-	-	99.6	-	85	Stabilized sludge	-
Louisville Gas & Electric	Mill Creek	4	425	7/79	Lime scrubbing	N	-	Coal	-	3.5–4.0	-	-	-	-	-	-	-
Alabama Electric Cooperative	Tombigbee	2	160	3/78	Limestone scrubbing	N	2	Coal	-	0.8-1.5	-	ESP	-	-	-	-	-
Alabama Electric Cooperative	Tombigbee	3	160	3/79	Limestone scrubbing	N	2	Coal	-	0.8-1.5	-	ESP	-	-	-	-	-
Arizona Electric Power Cooperative	Apache	2	200	6/78	Limestone scrubbing	N	2	Coal	10,200	0.5-0.8	-	ESP	99.4	Packed tower	85	-	-
Arizona Electric Power Cooperative	Apache	3	200	6/79	Limestone scrubbing	N	2	Coal	10,200	0.5-0.8	-	ESP	99.4	Packed tower	85	-	-
Kansas Power & Light	Jeffery	1	340	6/78	Limestone scrubbing	N	-	Coal	8,000	0.32	6	ESP	90	Spray tower	60	-	-
Kansas Power & Light	Jeffery	2	340	6/79	Limestone scrubbing	N	-	Coal	8,000	0.32	6	ESP	-	-	-	-	-
Central Illinois Public Service	Newton	1	575	7/78	Sodium-lime double alkali	N	4	Coal	10,900	4.0-0.2 Cl.	-	ESP, cocurrent spray precoolers	99.5	Two-tray mobile-ball scrubber	95	Unstabilized filter cake	-
Central Illinois Light	Duck Creek	1	400	8/78	Limestone scrubbing	N	4	Coal	-	0.6	-	ESP	99.8	Packed-rod venturi	75	-	-
Allegheny Power System	Pleasants	1	625	3/79	Lime scrubbing	N	4	Coal	-	4.5 max.	-	ESP, venturi scrubber	99.5	Perforated-plate reaction tray	90	Stabilized sludge	-
Allegheny Power System	Pleasants	2	625	3/80	Lime scrubbing	N	4	Coal	-	4.5 max.	-	ESP, venturi scrubber	99.5	Perforated-plate reaction tray	90	Stabilized sludge	-

TABLE 2. SUMMARY OF INFORMATION FOR FGD SYSTEMS IN OPERATION IN THE U.S.

Power plant			FGD installation					Fuel				Pollution removal				FGD product	
												Particulate		SO_2			
Utility	Station	Boiler No.	FGD MW	FGD startup	Process	New or retrofit	Total trains	Type	Btu/lb	% S	% ash	Device	%	Device	%	Material	Disposal
Kansas City Power & Light	Lawrence	4	125	12/68, 1/77	Limestone scrubbing	R	1	Coal (gas-oil)	10,000	0.5	11	ESP, venturi rod	99	Spray tower	75	Unstabilized sludge	Unlined pond
Kansas City Power & Light	Lawrence	5	400	11/71, 6/78	Limestone injection	N	8,2	Coal (gas-oil)	10,000	0.5	11	Single-stage marble bed	99	Single-stage marble bed	65	Unstabilized sludge	Unlined pond
Commonwealth Edison	Will County	1	167	2/72	Limestone scrubbing	R	2	Coal	9,463	2.0-3.5	15	ESP, variable-throat venturi	98	A-tray absorber B-TCA	82	Stabilized sludge	Clay-lined pond
Kansas City Power & Light	Hawthorn	4	90	8/72, 1/77	Lime scrubbing	R	2	Coal (gas)	9,800 11,400	0.6-3.0	11-14	Marble bed	99	Marble bed	70	Unstabilized sludge	Unlined pond
Kansas City Power & Light	Hawthorn	3	90	11/72, 1/77	Lime scrubbing	R	2	Coal (gas)	9,800 11,400	0.6-3.0	11-14	Marble bed	99	Marble bed	70	Unstabilized sludge	Unlined pond
Kansas City Power & Light	La Cygne	1	820	2/73	Limestone scrubbing	N	8	Coal	9,000 9,700	3.0-6.0	15-30	Variable-throat venturi	98	Perforated-plate reaction tray	72	Unstabilized sludge	Unlined pond
Louisville Gas & Electric	Cane Run	4	178	8/76	Carbide lime scrubbing	R	2	Coal	11,500	3.5-4.0	11-12	ESP	99	Mobile-bed contactor	90	Stabilized sludge	Unlined pond
Duquesne Light	Phillips	1-6	410	7/73	Lime scrubbing	R	4	Coal	11,350	1.0-2.8	18.2	ESP, variable-throat venturi	99	Three single-stage & one dual-stage venturis	83	Stabilized sludge	Unlined pond
Duquesne Light	Elrama	1-2	510	10/75, 2/76	Lime scrubbing	R	5	Coal		1.0-2.8		ESP, venturi scrubber		Single-stage venturi scrubber	83	Stabilized sludge	Unlined pond
Arizona Public Service	Cholla	1	115	10/73	Limestone scrubbing	R	1	Coal	12,146	0.4-1.0	12.3	Flooded-disc venturi scrubber	99.7	Packed tower	76	Unstabilized sludge	Unlined pond
Nevada Power	Reid Gardner	2	125	12/73	Sodium carbonate scrubbing	R	1	Coal	12,450	0.5-1.0	8-10	Multicyclone & two parallel venturi scrubbers	99.4	Single-stage wash tray	85	Spent liquor	Unlined pond
Nevada Power	Reid Gardner	1	125	4/74	Sodium carbonate scrubbing	R	1	Coal	12,450	0.5-1.0	8-10	Multicyclone & two parallel venturi scrubbers		Single-stage wash tray	85	Spent liquor	Unlined pond
Nevada Power	Reid Gardner	3	125	7/76	Sodium carbonate scrubbing	N	1	Coal	12,450	0.5-1.0		Multicyclone & two parallel venturi scrubbers	79	Single-stage wash tray	85	Spent liquor	Unlined pond
Kentucky Utilities	Green River	1-3	64	9/75	Lime scrubbing	R	1	Coal	11,000	3.5-4.0		Variable-throat venturi scrubber	99.7	Ten-compartment mobile bed	80	Stabilized sludge	Unlined pond
Montana Power Company	Colstrip	1	360	10/75	Lime-alkaline flyash scrubbing	N	3	Coal	8,800	0.8		Variable-throat venturi scrubber	99	Variable-throat venturi scrubber	88	Unstabilized sludge	Unlined pond

(continued)

TABLE 2 (continued)

Power plant			FGD installation					Fuel				Pollution removal				FGD product	
												Particulate		SO_2			
Utility	Station	Boiler No.	FGD MW	FGD startup	Process	New or retrofit	Total trains	Type	Btu/lb	% S	% ash	Device	%	Device	%	Material	Disposal
Montana Power	Colstrip	2	360	7/76	Lime-alkaline flyash scrubbing	N	3	Coal	8,800	0.8		Variable-throat venturi scrubber	99	Variable-throat venturi scrubber	88	Unstabilized sludge	Unlined pond
Northern States Power	Sherburne	1	700	3/76	Limestone-alkaline flyash scrubbing	N	12	Coal	8,300	0.8	9	Fixed & adjustable rod venturi	99	Single-stage marble bed	50	Oxidized, unstabilized sludge	Lined pond
Pennsylvania Power	Bruce Mansfield	1	835	4/76	Lime scrubbing	N	6	Coal	11,900	3.0-4.5	8-15	Variable-throat venturi scrubber	99.8	Fixed-throat venturi scrubber	92	Stabilized sludge	Unlined pond
Columbus & So. Ohio Electric	Conesville	5	400	2/77	Lime scrubbing	N	3	Coal	10,800	4.5-4.9	15	ESP	99.5	Two-bed TCA	89.6	Stabilized sludge	Lined pond
Northern States Power	Sherburne	2	680	4/77	Limestone scrubbing	N	12	Coal	8,300	0.8	9	Fixed-rod venturi	99	Single-stage marble bed	50	Unstabilized sludge	Lined pond
Tennessee Valley Authority	Widows Creek	8	550	5/77	Limestone scrubbing	R	4	Coal	10,000	3.7	25	ESP, variable-throat venturi scrubber	99.0	Grid tower or TCA	75	Unstabilized sludge	Pond

TABLE 3. PROJECTS IN FGD WASTE AND WATER PROGRAM

Project	Contractor	Primary area of interest
FGC waste characterization and disposal evaluation	The Aerospace Corporation El Segundo, California	Environmental assessment
Shawnee FGD waste disposal field evaluation	Tennessee Valley Authority Division of Chemical Development Muscle Shoals, Alabama	Environmental assessment
	The Aerospace Corporation El Segundo, California	
Laboratory and field evaluation of FGC treatment processes	U.S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	Environmental assessment
Characterization of effluents from coal-fired power plants	Tennessee Valley Authority Power Research Staff Chattanooga, Tennessee	Environmental assessment
Flyash characterization and disposal	Tennessee Valley Authority Power Research Staff Chattanooga, Tennessee	Environmental assessment
Attenuation of FGC waste leachate by soils	U.S. Army Material Command Dugway Proving Ground, Utah	Environmental assessment
Establishment of data base for FGC disposal standards	SCS Engineers Long Beach, California	Environmental assessment
Evaluation of FGD waste disposal options	Louisville Gas and Electric Company Louisville, Kentucky	Technology assessment and development
FGD waste leachate - liner compatibility	U.S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	Technology assessment and development
Scrubber waste characterization	Tennessee Valley Authority Power Research Staff Chattanooga, Tennessee	Technology assessment and development
Dewatering principles and equipment design	Auburn University Auburn, Alabama	Technology assessment and development
Conceptual design-cost studies of alternative methods for FGC waste disposal	Tennessee Valley Authority Office of Agricultural and Chemical Development Muscle Shoals, Alabama	Economic study
Gypsum byproduct marketing studies	Tennessee Valley Authority Office of Agricultural and Chemical Development Muscle Shoals, Alabama	Economic study
Evaluation of alternative FGC waste disposal sites	Arthur D. Little, Inc. Cambridge, Massachusetts	Alternative disposal methods
Scrubbing waste conversion studies	Pullman Kellogg Company Houston, Texas	Utilization methods development
Fertilizer production using scrubbing wastes	Tennessee Valley Authority Office of Agricultural and Chemical Development Muscle Shoals, Alabama	Utilization methods development
Use of FGD gypsum in Portland cement	South Carolina Public Service Authority Moncks Corner, South Carolina	Utilization methods development
	Santee Portland Cement Corporation Holly Hill, South Carolina	
	Babcock & Wilcox Barberton, Ohio	
FGD waste and flyash beneficiation	TRW Systems Group Redondo Beach, California	Utilization methods development
Assess and demonstrate power plant water reuse and recycle	Radian, Inc. Austin, Texas	Overall power plant water use

The first is untreated sludge disposal, with the base case being the direct ponding (without prior dewatering) of untreated, scrubber system effluent in a clay-lined pond located 1 mi from the scrubber facilities. Case variations include (1) ponding of dewatered sludge, (2) use of an unlined pond, (3) distance of 5 and 10 mi to the disposal pond, and (4) sufficient dewatering to allow transport by truck to a landfill for disposal.

The second category is treated sludge disposal, using three proprietary processes (Dravo, IUCS, and Chemfix). The Dravo process base case is for the ponding of chemically treated dewatered sludge (containing 35% solids) in a clay-lined pond. The chemical treatment consists of adding adequate quantities of fixation materials to stabilize the settled slurry in the disposal pond. The stabilized material has physical properties similar to typical soil.

The IUCS and Chemfix processes involve dewatering to form a 60% solids material and mixing this cake with additives to produce a soillike material which can be easily handled, transported, and compacted in a landfill disposal area.

The technologies associated with these disposal alternatives are currently being applied by several utilities on either a full- or demonstration-scale size. Sufficient information is available concerning equipment, materials, and design parameters to make meaningful cost estimates (2, 12).

All cost estimates are based on the latest available process and equipment development, design, and economic information. A wide range of case variations was considered for each of the four disposal alternatives so that the cost estimates may be used by the utility industry to reflect trends generally applicable to most power plants in the U.S. (13). A specific base case is discussed in detail for each process. The evaluation of each process included developing flow and instrumentation diagrams, material balance, equipment list and layouts, and detailed capital investment and revenue requirement breakdowns.

Case variation cost estimates for each disposal alternative provide data for sensitivity analysis. The effect of changes in design and economic premises for the base cases include power plant size and remaining life, sulfur (S) and ash content of coal, distance and mode of transportation to disposal site, type of pond liner, and quantity of sludge for disposal.

PROCESS BACKGROUND AND DESCRIPTION

Alternatives for disposal of FGD sludges currently being considered by the utility industry are ponding and landfilling (including mine disposal). In selecting alternatives, an evaluation of pertinent plant conditions and factors, such as land availability, soil characteristics, sludge properties, and environmental regulations, must be made (14).

Sludge may contain trace elements and dissolved salts which in an unstabilized state could contaminate surface or ground water. The ability of soil to prevent the leaching of harmful constituents into water supplies is not well understood (15). Therefore, the impoundment (pond or landfill) of sludge must be accompanied by specific safeguards that allow a significant margin of safety to prevent seepage. A number of studies are underway (2) at this time that will provide more usable information concerning water supply contamination, soil leaching mechanics, and their effect upon sludge disposal.

The disposal processes considered in this study are believed to represent a range of alternatives that reflect the necessary economic trends which would allow the more desirable options to be identified for a variety of plant characteristics (13). As stated earlier, the conditions for each specific plant site vary and factors such as land availability, soil characteristics, sludge properties, and environmental regulations, will determine the most desirable disposal option.

The sludge being considered for disposal in this study is produced by lime and limestone FGD systems. Flyash is removed with the SO_2 in the scrubber system in all base case alternatives. One variation of each primary disposal method will be disposal of sludge from a scrubber system downstream of an electrostatic precipitator (ESP). In this variation almost all of the flyash is removed and, therefore, it has not been included in the material for disposal (IUCS is an exception because dry flyash is added to the dewatered sludge with lime to stabilize the material).

UNTREATED SLUDGE

Untreated sludge is material that has not been treated with chemical additives to change chemical or physical characteristics. Typical ranges of composition for untreated sludge are as follows: flyash (5-50%), calcium sulfite (25-40%), calcium sulfate (4-8%), unreacted lime or limestone (5-20%). These percentages are based on dry sludge analysis.

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The untreated sludge can be pumped to a pond for impoundment or it can be dewatered with thickeners and filters for transport by truck, rail, or barge to a disposal site (landfill, ocean, mine, ravine, etc.). The options being considered in this study include ponding a 10, 15, or 35% solids slurry in a lined or unlined pond and landfill disposal of 60% solids sludge.

Ponding

Sludge ponds may be lined with clay, synthetic material, or treated sludge. In some situations, it may be possible to pond without using a liner. In these alternatives, the effect of leachate on the water supplies in the general area of the pond should be monitored to determine the extent of contamination, if any. Experience shows (16) that in many cases an unlined pond is not environmentally acceptable and a liner is needed. The sludge is allowed to settle in the pond as a 40-60% solids material. The settled sludge is a mudlike material that cannot support loads normally supported by typical soil. This sludge can be covered with a layer of water to improve safety and aesthetic requirements. Water can be recycled from the pond to the scrubber facility as scrubber slurry makeup water. In most cases the recycle water cannot be put back into the natural water system due to higher than acceptable levels of dissolved solids and trace elements.

Landfill

In this study it is assumed that a dewatered untreated material containing 60% solids can be handled with belt conveyors, trucks, and earthmoving equipment. This material is similar to moist clay soil and allows a landfill disposal option to be used for untreated sludge. The addition of water or excessive mechanical working will result in the return of the sludge to a fluid state that makes handling difficult. These two restrictions must be considered for the landfill disposal of untreated sludge. The material can contaminate ground and surface water supplies if care is not taken to assure minimum runoff and seepage from exposed areas of untreated sludge landfill. Although the landfill area may be reclaimed by covering it with a layer of soil and vegetation, it is necessary that the reclaimed land be contoured to control the flow of rainwater through the reclaimed area (17).

TREATED SLUDGE

There are three companies that have developed technology for the chemical fixation of a wide variety of sludge materials. These companies are Dravo, IUCS, and Chemfix. These companies have each conducted studies with lime-limestone FGD sludges and two (Dravo and IUCS) now have full-scale operating plants for the processing and disposal of power plant FGD sludge. In each case, a material is produced that offers improvement over the untreated sludge. The treated material is easier to handle, has lower permeability and solubility, thereby reducing the problem of contamination of surface and ground water supplies, and can be placed in a landfill which can later be reclaimed for commercial use (18). Each of the three fixation processes uses a different type of chemical reaction system to achieve stabilization and fixation of the sludge (19).

The product of fixation is also different for the three processes. Chemfix produces a material with soillike characteristics while Dravo produces a claylike material and IUCS, a clay-concrete-type material. The properties of each final product can be changed with a variation in either the addition of fixation materials or sludge properties.

Dravo

Dravo offers a process for the chemical fixation of FGD sludge by mixing the untreated sludge with granulated blast furnace slag and lime. The inclusion of these two additives--Calcilox (granulated blast furnace slag) and Thiosorbic lime (lime with higher than normal MgO content)--with dewatered sludge containing 35% solids results in the stabilization of the sludge. This process is patented by Dravo as the Synearth process (20, 21).

Sludge produced in a lime or limestone FGD system is especially difficult to handle because of certain physical characteristics. The sludge in the thickener underflow contains about 35% solids which are very fine particles. Calcilox and Thiosorbic lime are added to the sludge at which time complex chemical reactions begin and continue to occur over several days (1-21) between the Calcilox, Thiosorbic lime, and various sludge components. These pozzolanic reactions result in the formation of a crystalline interlacing structure of molecules which ties up water molecules and yields a solid, stable material.

Immediately after the mixing of the two additives with sludge, there is no apparent change in the physical or chemical properties of the sludge. The material can be pumped to an impoundment for ultimate disposal. The solids will settle from the 35% solids slurry to form a material containing about 50% solids. The excess water can be recycled for use in scrubber slurry makeup. The settled sludge will gradually solidify. During this stabilization period the aesthetic acceptability is enhanced by a covering of water over the settled slurry; this water will not impede the stabilization process. The rate of solidification can be controlled by varying the quantities of Calcilox and Thiosorbic lime added and by varying the percent solids in the slurry before the additive mixing step. After the impoundment area is completely filled with treated sludge, it can be used for light industrial and residential construction (14).

To obtain a fixed sludge suitable for ponding and ultimate reclamation for light construction, Calcilox is added in the amount of 7% of the weight of dry solids in the sludge and Thiosorbic lime, 1%. The treated sludge has properties similar to silty clay with water permeation of approximately 2×10^{-5} cm/sec. Permeability, bearing strength, and other physical and engineering properties can be manipulated by varying the amount of additive (20).

Although several power plants are now using this Dravo fixation scheme, other schemes are also offered by Dravo, i.e., a material suitable for landfill can be produced with additional dewatering and increased additive amounts. The resulting landfill material is suitable for hauling by truck to a disposal area where it is handled using typical landfill earthmoving equipment. Another scheme requires intermediate ponding of treated sludge (35% solids) for 15-30 days in small curing ponds before transport by truck to a landfill for ultimate disposal.

IUCS

IUCS offers a complete waste system (patented as Poz-O-Tec process) that can be used for the disposal of sludge produced by lime or limestone FGD systems. The process requires that the scrubber underflow slurry be dewatered through thickening and filtration to form a 60% solids material which is then mixed with lime for stabilization. The dewatered sludge must contain flyash, which may be added at the mixer or may have been included in the scrubber underflow. Two primary reactions are responsible for the sludge fixation. The first reaction occurs within the first 24-72 hr following mixing and results in the formation of a fibrous gypsum with low permeability (10^{-5} cm/sec) and improved bearing properties. This reaction is between lime and soluble sulfates. The second reaction is between the silica-alumina components of the flyash and the lime compounds. This reaction occurring over several months involves pozzolanic reactions and results in a significant improvement in structural and engineering properties. The reaction is a function of temperature and at temperatures below 40°F is somewhat inactive; however, no permanent impairment of the sludge fixation process occurs below 40°F, and the reaction continues at a normal rate when the temperature rises above 40°F. A variety of materials produced by the IUCS process includes landfill material for ravines and strip mines, impermeable pond liner, and road base material. The type of final product depends upon the quantity of lime added and the chemical and physical characteristics of the untreated sludge (5, 7).

The FGD sludge produced in the lime-limestone scrubber under consideration in this study is treated with a quantity of lime equal to 4% of the total dry solids in the sludge. The stabilized material is reported by IUCS to be suitable for landfill disposal (22, 23).

For landfill disposal, the sludge is treated such that its physical characteristics are similar to a claylike soil. The sludge is structurally acceptable for handling with belt conveyors, hauling by truck, and placement in a landfill with typical earthmoving equipment. The product of the IUCS process has a more clay-concretelike character than the products of other fixation processes.

For a landfill to be environmentally acceptable, the leachate passing through the disposal material must meet certain physical and chemical property requirements. The quantity of leachate from a landfill with sludge treated by IUCS is very low since the treated sludge has claylike characteristics. IUCS has reported that leachate samples were found to contain very low concentrations of objectionable trace elements and dissolved solids (22).

Sludge used for landfill must meet certain engineering property requirements. IUCS-treated sludge is reported to be suitable with respect to these parameters. Bearing quality and unconfined compressive strength measurements have been made and are indicated by IUCS as being within acceptable limits. These properties are also a function of the additive quantities and the untreated sludge physical and chemical properties.

IUCS reports that the Poz-O-Pac process has been successfully used for 20 yr to produce a road-base material from flyash and that several utilities are now using the IUCS Poz-O-Tec process (based on Poz-O-Pac process) on a full scale for disposal of FGD scrubber sludge. These utilities include Duquesne Power and Light's Elrama and Phillips stations and the Columbus and Southern Ohio's Conesville plant (8).

Chemfix

The Chemfix process uses a two-part, inorganic chemical system which reacts with all polyvalent metal ions and with certain other waste components. This patented system is based on the reaction between soluble silicates, i.e., sodium silicate, and silicate setting agents, i.e., Portland cement, which react in a controlled manner to produce a solid matrix. The reaction between these chemical compounds occurs at normal ambient temperatures and is reportedly not affected by temperature variations. No heating or other special conditions, such as pressure, catalysis, or long residence times, are necessary (9).

Three classes of interactions are responsible for the fixation of solidification of the sludge. The chemistry of these reactions is very complex. The first reaction is between soluble silicates (added to sludge) and polyvalent metal ions. The second set of reactions occurs between the soluble silicate and the reactive components of the setting agent. The reaction results in the formation of a gel. As a result of the water being contained in the gel, the material tends to solidify. The final reaction is between the setting agent and the various components of the sludge. This reaction results in further stabilization, both chemically and physically. The rate and extent of each of these three reactions are functions of additive type and amount and sludge chemical and physical properties.

There are several chemical systems which react with various wastes to encapsulate, immobilize, or otherwise tie up wastes. There are also several silicate setting agents and soluble silicates that may be selected to obtain the desired results. For sludge produced in a lime or limestone FGD process, sodium silicate is the soluble silicate and Portland cement is the silicate setting agent. The quantity of these two materials added to the untreated sludge depends upon the time allowed for fixation, chemical and physical properties of the sludge, and desired product physical, engineering, and chemical properties (24).

The desired product for this study is an earthlike material that can be used for typical landfill. The material's physical properties must allow handling with belt conveyors, hauling by truck, and placement and compaction in a landfill with common earthmoving equipment. Tests conducted on lime and limestone FGD sludges have indicated that the quantity of sodium silicate and Portland cement to be added must be about 4 and 7% by wt, respectively, of the dry sludge quantity. The soillike product of this process is suitable for landfill disposal and has fairly good bearing properties following initial placement and compaction in the landfill. The treated sludge tends to degrade structurally if the material is dug up and moved and a loss of strength occurs.

Stabilization is primarily a function of additive amounts and type. Also, the rate of solidification is controlled with amounts of additives and the reactions are not dependent upon the presence of flyash as in the IUCS process. Analyses of leachates from disposal areas in tests conducted by Chemfix and preliminary test results of others show that quality of the leachate can be adjusted within acceptable standards by varying the quantity of additives mixed with the sludge. The landfill area may also be reclaimed and revegetated.

The process has been successfully demonstrated in full-scale application to wastes from metal finishing, electronics fabrication, automotive assembly, and municipal sewage treatment (25).

DESIGN AND ECONOMIC PREMISES

An accurate comparison of several sludge disposal processes can be made only if a specific set of design and economic premises is established and used as a basis for the design and economic calculations. Through the use of parameter studies (as compared to using only a single set of preselected base case conditions) evaluations can be made without giving advantage to a particular process. The pertinent design and economic premises concerning the operation of power plant, the FGD system, and the sludge disposal system are discussed in this section of the report.

DESIGN PREMISES

A base case of design premises was established for each sludge disposal alternative. The premises for the power plant are the same for all disposal alternatives, making this basis for comparison equal for the alternatives.

Power Plant

Design premises for power plant stack gas emission control studies have been established in 1976 by TVA and EPA in work conducted prior to this study for use in general technical and economic evaluations of power plant emission control technology. These premises with appropriate additions and minor adjustments are also used for this evaluation.

Fuel--

A range of values for coal S and ash contents is considered in this study. The effects of S contents of 2.0, 3.5, and 5.0% (dry basis) and ash contents of 12, 16, and 20% (wet basis) are evaluated. The base case S and ash contents of the coal are 3.5 and 16% respectively. The complete composition for the base case coal and the amounts used for operation of a 500-MW unit are as follows:

Component	Composition as fired, wt %	500-MW unit requirements, lb/hr
C	57.56	246,800
H_2	4.14	17,700
N_2	1.29	5,500
O_2	7.00	30,000
S	3.12	13,400
Cl	0.15	600
Ash	16.00	68,600
H_2O	10.74	46,000
Total	100.00	428,600

This coal has a heating value of about 10,500 Btu/lb (as fired).

Plant Size--

Three power station capacities are evaluated to determine the effect of size on the economics of sludge disposal. The base case is a 500-MW unit. Although most future stations will probably have capacities of 500-MW or larger, 200-MW and smaller units will continue to be used. Therefore, power station capacities of 200-, 500-, and 1500-MW are considered in this study. The 1500-MW station is assumed to be three 500-MW units.

Power Unit Life, Operating Time, and Capacity--

For each power station capacity used in the evaluation, a range of values for operating life is considered. The base case is a new 500-MW plant. New plants are estimated to have a 30-yr life, based on guidelines suggested by the Federal Power Commission (FPC) (26). Power unit operating schedules that reflect TVA experience are shown below.

Years of life	Capacity factor, % (nameplate rating)	Annual operating time, hr
1-10	80	7,000
11-15	57	5,000
16-20	40	3,500
21-30	17	1,500
Average for 30-yr life	48.5	4,250

Existing units with remaining lives of 25 yr (92,500 hr), 20 yr (57,500 hr) and 15 yr (32,500 hr) are also considered. Table 4 lists the representative heat values used in this study.

FGD System

The application of FGD systems in the U.S. is accelerating and a very large percentage of these systems involve the lime and limestone wet-scrubbing process. The premises used for this process are described in the following discussion.

Lime and Limestone Scrubbers--

Both of these processes remove SO_2 from power plant flue gas by contacting the gas with a recirculating slurry stream that contains either slaked lime or wet ground limestone. The first stage of slurry circulation is for flue gas cooling and particulate removal and the second stage is for SO_2 removal. Overflow from this second stage reaction loop is fed to the first stage loop.

The stoichiometric ratio of the $CaO:SO_2$ removal for the limestone process is 1.5; in the lime process a ratio of 1.1 is used.

Spent slurry, consisting of calcium compounds, unreacted lime or limestone, and flyash, is pumped to a hold tank and subsequently to disposal.

Flue Gas Composition--

Flue gas compositions are based on the combustion of coal with an excess air amount of 20% of the stoichiometric requirement and air leakage into the flue gas at the air preheater of 13% of the stoichiometric combustion requirement. The total amount of air to the power plant system is 133% of the stoichiometric amount. These values reflect operating experience with TVA horizontal, frontal-fired, coal-burning units.

TABLE 4. POWER UNIT INPUT HEAT REQUIREMENTS

Unit size, MW	Status	Heat rate, Btu/kWh
500	New	9,000
500	Existing	9,200
200	New	9,200
200	Existing	9,500

It is assumed that 80% of the ash present in the coal is emitted as flyash and about 95% of the S in the coal is emitted as SO_2. Table 5 includes information concerning coal composition and its corresponding flue gas composition for 2.0, 3.5, and 5.0% S coals. In each case the coal heating value is 10,500 Btu/lb.

Emission Standards--

The following are emission standards for new steam-generating facilities set by EPA (27).

	Allowable emission, lb/MBtu heat input
Particulates	0.1
SO_2	1.2

TABLE 5. COAL AND FLUE GAS COMPOSITIONS AND AMOUNTS FOR VARIOUS S CONTENTS IN COAL (500-MW UNIT)

	S content in coal (dry basis)					
	2%		3.5%		5%	
Coal composition[a,b]	Wt %	Lb/hr	Wt %	Lb/hr	Wt %	Lb/hr
C	58.03	248,700	57.56	246,800	56.89	244,000
H_2	4.17	17,900	4.14	17,700	4.09	17,500
N_2	1.30	5,600	1.29	5,500	1.27	5,400
O_2	7.81	33,500	7.00	30,000	6.40	27,400
S	1.80	7,700	3.12	13,400	4.46	19,100
Cl	0.15	600	0.15	600	0.15	600
Ash	16.00	68,600	16.00	68,600	16.00	68,600
H_2O	10.74	46,000	10.74	46,000	10.74	46,000
Total	100.00	428,600	100.00	428,600	100.00	428,600

Flue gas composition	Vol %	Lb/hr	Aft^3/min (300°F)	Vol %	Lb/hr	Aft^3/min (300°F)	Vol %	Lb/hr	Aft^3/min (300°F)
N_2	73.68	3,439,000	1,134,000	73.76	3,450,000	1,138,000	73.80	3,443,000	1,136,000
O_2	4.83	257,400	74,350	4.83	258,200	74,590	4.84	257,800	74,460
CO_2	12.44	911,600	191,400	12.31	904,200	189,900	12.20	894,700	187,700
SO_2	0.14	14,500	2,092	0.24	25,130	3,626	0.34	35,920	5,183
SO_3	0.0014	183	21	0.0024	317	37	0.0034	454	52
NO	0.06	3,002	924	0.06	3,009	927	0.06	3,000	924
HCl	0.01	661	168	0.01	661	168	0.01	661	168
H_2O	8.84	265,400	136,100	8.79	264,500	135,600	8.75	262,400	134,600
Total	100.00	4,892,000	1,539,000	100.00	4,906,000	1,543,000	100.00	4,898,000	1,539,000
Flyash loading. gr/sft^3									
Dry		6.67			6.65			6.66	
Wet		6.08			6.06			6.08	

a. HHV = 10,500 Btu/lb.
b. As fired basis.

The required amount of SO_2 to be removed varies with the S content of the coal used. Design provisions necessary to meet only the emission standards have been provided; therefore, the degree of SO_2 removal ranges between 65 and 85% of the SO_2 entering the FGD system.

Sludge Disposal System

The spent slurry from the limestone FGD scrubber is assumed to contain 15% solids and from the lime scrubber, 10% solids. These solids contents include the flyash removed. The removal of flyash with the calcium solids is assumed in all cases, except those schemes which remove dry flyash in an ESP. In the latter cases, the flyash is not included as a component of the sludge.

The sludge disposal system consists of all equipment used for the disposal of spent slurry from the scrubber system. The hold tank for spent slurry from the scrubber system is the first item considered as part of the disposal system area.

Spent calcium solids slurry from the FGD system is assumed to be primarily calcium sulfite hemihydrate. The sulfite ion may be ultimately converted by oxidation to gypsum or calcium sulfate dihydrate. It is assumed that 15% of the total SO_2 removed is ultimately converted to calcium sulfate dihydrate. These two constituents of sludge are often referred to as sulfite and sulfate sludge components.

Untreated Sludge Disposal--

The base case for the disposal of untreated limestone sludge is direct ponding of spent slurry (containing 15% solids) from the scrubber in a pond lined with 12 in. of impervious clay. Pond life is the same as the power plant's remaining life. Also, pond depth is determined such that excavation and land costs are optimized. The sludge is assumed to settle in the pond as a material containing 50% solids. Excess water is recycled back to the scrubber system. Pond evaporation and seepage is assumed to equal rainfall. The distance from the disposal site to the pond is 1 mi and the average pond depth is about 20 ft.

Dravo Process--

The Dravo process base case is for disposing treated sludge containing 35% solids in a pond lined with 12 in. of impervious clay. The pond life is assumed to be the same as the power plant's remaining life. Pond depth is determined such that excavation and land costs are optimized. Treated sludge is assumed to settle as a material containing 50% solids and excess water is recycled to the scrubber facility. Fixation occurs in the settled slurry and the final material has properties similar to typical soil. The pond is located 1 mi from the scrubber and the treated sludge is pumped to the pond. The average pond depth is about 20 ft.

IUCS Process--

The base case IUCS process produces a stabilized sludge that is suitable for handling with typical earthmoving equipment and can be placed and compacted in a natural landfill area. It is assumed that the product for disposal has properties similar to a claylike soil and contains about 60% solids. The disposal site is 1 mi from the scrubber and the treated sludge is hauled by truck to the disposal area. The landfill depth is assumed to average 30 ft.

Chemfix Process--

Thickener underflow containing 35% solids is pumped to the Chemfix fixation facilities. The Chemfix facilities are located at the disposal site 1 mi from the scrubber system facilities. The product for disposal has properties similar to typical soil and can be handled with typical earthmoving equipment for landfill disposal (average depth of 30 ft). The water content of the treated material is about 40%.

Raw Materials--

All raw materials used in the three fixation properties are assumed to be received by either truck or rail transportation. Thirty-day storage facilities are provided for them. Feed bins, intermediate process tanks, etc., are designed for 8 hr of storage capacity.

Listed below are the raw materials along with their assumed typical characteristics used in the three fixation processes.

1. Lime (IUCS)

   Analysis: CaO (95%), SiO_2 (1%), MgO (2%)
   Particle size: Ground powder
   Bulk density: 60 lb/ft^3

2. Thiosorbic lime (Dravo)

   Analysis: CaO (93-97%), SiO_2 (1%), MgO (2-6%)
   Particle size: Pebble, minus 1-1/4 in. to 3/4 in.
   Bulk density: 55 lb/ft^3

3. Calcilox (Dravo)

   Analysis: SiO_2 (30-40%), CaO (40-50%), MgO (3-10%), Al_2O_3 (10-20%)
   Particle size: Finely ground powder
   Blaine specific surface (1,800-5,000 sq cm/g)
   Bulk density: 85 lb/ft^3

4. Portland cement (Chemfix)

   Analysis: CaO (60-64%), SiO_2 (20-24%), Al_2O_3 (5-6%), Fe_2O_3 (2-5%)
   Particle size: Finely ground powder
   Bulk density: 95 lb/ft^3

5. Sodium silicate (Chemfix)

   Analysis: Ratio of 1 Na_2O:322 SiO_2 solution, 38.3% sodium silicate, 61.7% water

   Specific gravity: Minus 1.401 or 41.5° Baumé

ECONOMIC PREMISES

The criteria affecting the economic evaluation of the disposal systems follow.

Plant Location

A midwestern plant location was selected so that results of this study will be based on similar assumptions made in earlier studies of this type. Raw materials are readily available in this area. Also, a large amount of coal-fired power generating capacity exists in the area.

Capital Investment

Capital investment estimates represent projects beginning mid-1977 and ending mid-1980, with an average cost basis for scaling of mid-1979. Direct investments are prepared using the average annual Chemical Engineering cost indexes and the projections shown in Table 6. Capital investment estimates are based on cost information obtained from engineering-contracting, processing, and equipment companies.

Other special provisions and assumptions needed to prepare uniform cost estimates are as follows:

1. Spare pumps are provided to prevent operational shutdowns due to pump failure. For all cases except IUCS, a spare pipeline is included for transport of sludge to the disposal area. No other spare equipment is included.
2. Equipment, material, and construction labor shortages with accompanying overtime pay incentive are not included in the capital investments.
3. The cost of land will appear as a separate listing under capital requirements.
4. Costs for the generation facilities for electricity and the FGD system are not included in the capital investment.

Direct Investment--

The cost of process equipment, piping and insulation, transport lines, foundations and structural, excavation, site preparation, roads and railroads, electrical, instrumentation, buildings, services, and pond construction are included as the direct investment portion of the total capital investment. The cost of both materials and labor for installation is included for each equipment item. Services are estimated at 1.5% of the total direct investment excluding the cost of pond construction. This item of cost includes allocated costs from the power plant for the use of maintenance shops, stores, communications, security, and offices, using current TVA practice as a guide. Parking lots, walkways, landscaping, fencing, and vehicles are also considered in this estimate for service facilities. Railroad facilities vary with each process depending upon raw material usage. Road requirements depend primarily

TABLE 6. COST INDEXES AND PROJECTIONS

Year	1970	1971	1972	1973	1974	1975	1976[a]	1977[a]	1978[a]	1979[a]	1980[a]	1981[a]
Plant	125.7	132.3	137.2	144.1	165.4	182.4	197.9	214.7	232.9	251.5	271.6	293.3
Material[b]	123.8	130.4	135.4	141.9	171.2	194.7	210.3	227.1	245.3	264.9	286.1	309.0
Labor[c]	137.4	146.2	152.2	157.9	163.3	168.6	183.8	200.3	218.3	237.9	259.3	282.6

a. Projections.
b. Same as index in *Chemical Engineering* for "equipment, machinery, supports."
c. Same as index in *Chemical Engineering* for "construction labor."

upon the type process, i.e., ponding, landfill, and the distance to the disposal area. Other direct investment items are discussed in greater detail in the Systems Estimated section of the report.

Indirect Investment--

The indirect investment items include the following:

- Engineering design and supervision
- Architect and engineering contractor expenses
- Construction expense
- Contractor fees
- Contingency
- Allowance for startup and modifications
- Interest during construction

Engineering design and supervision--An estimate of this cost was made using a technique that correlates the number of major equipment items with drafting room man-hr and engineering design costs. A separate procedure was used to determine this expense for the construction of disposal ponds. For pond engineering and design costs, a correlation between direct pond cost and engineering and design expense was determined for a range of pond sizes. From this relationship each case was estimated. A similar exception is made for cases that use landfill disposal. The engineering design and supervision cost for these cases is based on major equipment items excluding earthmoving equipment.

Architect and engineering contractor expenses--This cost is based directly upon the costs of engineering design and supervision. Again, it is necessary to differentiate between indirect costs for major equipment items and for pond construction or landfill costs. For the cases involving pond construction, 25% of the portion of the engineering design and supervision expense associated with major equipment is estimated for architect and engineering contractor (A&E) expense for major equipment and 10% of engineering design and construction expense associated with the disposal pond construction is estimated as an additional A&E expense. For the cases involving landfill systems, 25% of the total engineering design and supervision expense is used as the A&E expenses.

Contractor fees--A correlation between contractor fees and total direct investment for the project was used to estimate the cost of contractor fees. This relationship is as follows:

$$\text{contractor fees} = 0.096\ (a)^{0.76}$$

where a = direct investment in M$

Construction expense--A relationship, based on typical information found in the literature, was found to exist between construction expense and direct investment. The following equation was used to estimate construction expense.

$$\text{construction expense} = 0.25\ (b)^{0.83} + 0.13\ (c)^{0.83}$$

where b = direct investment excluding pond or landfill equipment costs in M$

c = direct pond cost in M$

Contingency--The contingency is assumed to be 20% of the total of direct investment, engineering design and supervision costs, architect and engineering contractor expenses, contractor fees, and construction expense.

Allowance for startup and modification--This expense is 10% of direct investment excluding pond construction plus all other indirect investment costs except interest during construction.

Interest during construction--This item was estimated to be 12% of direct investment plus all other indirect investment costs. This percentage is calculated as the simple interest which would be accumulated at a 10%/yr rate assuming an incremental capital structure of 60% debt-40% equity and a 3-yr project expenditure schedule as indicated in Table 7.

TABLE 7. PROJECT EXPENDITURE SCHEDULE

	Year			
	1	2	3	Total
Fraction of total expenditure as borrowed funds	0.15	0.30	0.15	0.60
Simple interest at 10%/yr as % of total expenditure				
Year 1 debt	1.5	1.5	1.5	4.5
Year 2 debt	-	3.0	3.0	6.0
Year 3 debt	-	-	1.5	1.5
Accumulated interest as % of total expenditure	1.5	4.5	6.0	12.0

Other Capital Charges--

The final two items that are estimated for each system evaluated are land and working capital.

Land--The cost of land is estimated at $3500/acre.

Working capital--Working capital consists of: (1) money invested in raw materials, supplies and finished products carried in stock, and semi-finished products in the process of being manufactured; (2) accounts receivable; (3) cash retained for payment of operating expenses, such as salaries, wages, and raw material purchases; (4) accounts payable; and (5) taxes payable.

For these premises, working capital is defined as the equivalent cost of 3 wk of raw material costs, 7 wk of direct costs, and 7 wk of overhead costs.

Revenue Requirements

The calculations relating to annual revenue requirements are based on 7000 hr of operation/yr. Process operation schedules are assumed to be the same as the power plant operating profiles and remaining life assumptions given in the power plant design premises.

Direct Costs--

Raw material, labor, utility, and maintenance costs considered are direct costs. These are projected to 1980 for this study.

Raw materials--Table 8 shows projected (1980) costs for the raw materials used in the three disposal systems involving sludge treatment.

TABLE 8. PROJECTED 1980 UNIT COSTS FOR RAW MATERIALS

Raw material	Cost, $/ton
Lime	
Pebble (IUCS process)	48.00
Ground (Thiosorbic, Dravo process)	51.00
Calcilox (Dravo process)	58.00
Portland cement (Chemfix process)	52.00
Sodium silicate (Chemfix process)	98.00

Labor--Table 9 shows the cost of labor for 1980.

TABLE 9. PROJECTED 1980 UNIT COSTS FOR LABOR

Type	Unit cost, $/man-hr
Plant operation and supervision	12.50
Analyses	17.00
Landfill equipment and truck operators	17.00

Land preparation--Another direct cost is the land preparation cost for those cases with landfill disposal. This cost covers the annual expense for preparing the disposal site for landfill (clearing, excavation, drainage, reclamation). This cost, based on the annual quantity of land used, is assumed to be $1700/acre.

Other direct costs--The cost of operating trucks and landfill equipment (fuel and maintenance) was estimated and projected to 1980. Truck operating costs vary depending upon distance traveled. The following are the rates tabulated for those cases requiring trucks for sludge transport.

Distance traveled, mi	Sludge transport cost, $/ton of wet sludge
1	0.06
5	0.20
10	0.39

The cost of fuel and maintenance is also estimated for the earthmoving equipment used in the landfill operation. These projected estimates are as follows:

Disposal system	Fuel and maintenance expense, $/ton of wet sludge
IUCS (no haul)	0.16
Chemfix (short haul, 1 mi)	0.30

The only utility item used by the estimated disposal system is electricity. The electricity rate varies with the size of the power plant-sludge disposal facility. For a 200-MW plant the unit cost is $0.031/kWh. The rate for a 500-MW plant is $0.029/kWh and for a 1500-MW plant, $0.027/kWh. Maintenance costs are estimated on the basis of direct investment and are varied for each process as a function of disposal method. For those disposal options requiring a pond, maintenance is estimated to be 4% of the direct investment (excluding pond construction) and 3% of the pond construction cost. The maintenance rate is 4% of total investment for all other cases (landfill disposal). Although maintenance costs increase with the age of a unit, they decrease as annual operating hr decline; therefore, maintenance costs are assumed to be constant over the entire life of the plant.

Indirect Costs--

The indirect costs include capital charges and overhead projected to 1980.

Capital charges--Tables 10 and 11 show a breakdown of capital charges for the sludge disposal systems evaluated in this study. The rate is different because of the considerable difference in interim replacement requirements for those processes requiring trucks and earthmoving equipment. This equipment is assumed to have a 6-yr life, and therefore, is replaced much more often than typical process equipment. In estimating the regulated capital charges associated with scrubber sludge disposal, the conventional method of considering the overall life of the power plant is used. The conclusion of the National Power Survey that a 30-yr service life is reasonable for steam-electric plants is recognized by FPC. FPC has designated interim replacements as an allowance factor in estimating annual revenue requirements for replacement of items with less than a 30-yr life. Use of this allowance, following FPC-recommended practice, provides for financing the cost of replacing such short-lived units. An average allowance of about 0.35% of the total investment is normally provided for steam-electric plants (26). However, to provide for the unknown life span of SO_2 scrubber sludge disposal facilities, a value of 0.7 is used for new units. These values are shown in Tables 10 and 11. An insurance and property tax allowance is also included in the capital charges based on FPC practice (2.0%). The depreciation rate is straight line based on the remaining life of the power plant after pollution control systems are installed.

TABLE 10. ANNUAL CAPITAL CHARGES FOR POWER INDUSTRY FINANCING

(LANDFILL DISPOSAL OF FIXED SLUDGE)

	Percentage of total depreciable capital investment			
Years remaining life	30	25	20	15
Depreciation-straight line (based on years remaining life of power unit)	3.3	4.0	5.0	6.7
Interim replacements (equipment having less than 30-yr life)	2.5	2.4	2.3	2.1
Insurance and property taxes	2.0	2.0	2.0	2.0
Total rate applied to original investment	7.8	8.8	9.3	10.8

	Percentage of unrecovered capital investment[a]
Cost of capital (capital structure assumed to be 60% debt and 40% equity)	
Bonds at 10% interest	6.0
Equity[b] at 14% return to stockholder	5.6
Income taxes (Federal and State)[c]	5.6
Total rate applied to depreciation base	17.2[d]

a. Original investment yet to be recovered or "written off."

b. Contains retained earnings and dividends.

c. Since income taxes are approximately 50% of gross return, the amount of taxes is the same as the return on equity.

d. Applied on an average basis, the total annual percentage of original fixed investment for new (30-yr) plants would be 7.8% + 1/2 (17.2%) = 16.4%.

TABLE 11. ANNUAL CAPITAL CHARGES FOR POWER INDUSTRY FINANCING

(POND DISPOSAL OF FGD SLUDGE)

	Percentage of total depreciable capital investment			
Years remaining life	30	25	20	15
Depreciation-straight line (based on years remaining life of power unit)	3.3	4.0	5.0	6.7
Interim replacements (equipment having less than 30-yr life)	0.7	0.4	-	-
Insurance and property taxes	2.0	2.0	2.0	2.0
Total rate applied to original investment	6.0	6.4	7.0	8.7

	Percentage of unrecovered capital investment[a]
Cost of capital (capital structure assumed to be 60% debt and 40% equity)	
Bonds at 10% interest	6.0
Equity[b] at 14% return to stockholder	5.6
Income taxes (Federal and State)[c]	5.6
Total rate applied to depreciation base	17.2[d]

a. Original investment yet to be recovered or "written off."

b. Contains retained earnings and dividends.

c. Since income taxes are approximately 50% of gross return, the amount of taxes is the same as the return on equity.

d. Applied on an average basis, the total annual percentage of original fixed investment for new (30-yr) plants would be 6.0% + 1/2 (17.2%) = 14.6%.

Another component of the capital charges for which variations may be expected is debt to equity ratio. FPC data indicate that the long-term debt for privately owned electric utilities varied only from 51.5 to 54.8% of total capitalization during the period 1965-73. However, recent economic upheavals have changed the incremental debt to equity ratio, as utilities are forced to depend more and more on bonds and bank loans for project funding. The capital structure for this study is assumed to be 60% debt and 40% equity. The interest rate for bonds is assumed to be 10% and the return to stockholders on equity, 14%. Cost of capital and income tax charges are applied to the uncovered portion of capital investment. Income taxes are 50% of the gross return, and the return on equity is 50% of gross return. Since return on equity is 5.6% (see Tables 10 and 11) of total capital investment, then income taxes are also 5.6% of total capital investment. Since most regulatory commissions base the annual permissible return on investment on the remaining depreciation base (that portion of original investment yet to be recovered or "written off"), a portion of the annual capital charge included in the lifetime operating cost declines uniformly over the life of the power plant.

Overhead--The cost of plant, administrative, and marketing overheads vary from company to company. Based on the various methods used by industry and suggested by cost estimating sources, the plant and administrative overall costs were assumed to be as follows (28, 29, 30): plant overhead--50% of the subtotal conversion costs less utilities (conversion costs include all direct costs except raw material costs); administrative overhead--10% of operating labor and supervision.

SYSTEMS ESTIMATED

This section of the report covers the estimates of systems for the four primary disposal alternatives--untreated sludge and the three treated sludge processes (Dravo, IUCS, and Chemfix). For each primary disposal alternative, 24-41 case variations have been estimated.

In evaluating these disposal alternatives, the following must be considered (31, 32).

- Material balances
- Flow diagrams
- Equipment lists and descriptions
- Instrumentation diagrams
- Layout drawings

The method for estimating costs for piping, electrical, instrumentation, pond feed, return lines, services, pond construction, foundation and structural, excavation, site preparation, roads and railroads, buildings, and services is discussed in this section of the report. Unless otherwise specified, the system is designed to handle both flyash and SO_2 sludge. Table 12 lists all cases for the disposal alternatives and the quantity of sludge for disposal (13).

UNTREATED SLUDGE

The ponding of FGD system spent slurry without chemical treatment or dewatering is the least complicated of the disposal alternatives considered in this study. Since this system involves only a few items of equipment the layout drawings, flow diagrams, and instrumentation diagrams are not presented in this report.

Underflow containing 15% solids from the scrubber system is pumped to an agitated pond feed tank. The slurry is then pumped 1 mi to a disposal pond where the slurry is allowed to settle to form a material containing 50% solids. Excess water is returned to the scrubber system for reuse. Carbon steel, rubber-lined pipelines are used to transport the sludge to the disposal pond, which is clay-lined to prevent leachate from the wastes from entering ground water. A material balance for the base untreated case is shown in Table 13 and provides information concerning each process stream.

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TABLE 12. QUANTITIES OF SLUDGE FOR DISPOSAL - ALL PROCESSES AND CASE VARIATIONS

Case	Yr life	Untreated disposal[a]		Dravo process[b]		IUCS process[c]		Chemfix process[d]	
		Dry, lb/hr	Wet, lb/hr	Dry, lb/hr	Wet, lb/hr	Dry, lb/hr	Wet, lb/hr	Dry, lb/hr	Wet, lb/hr
Base case[e]	30	116,000	232,000	125,000	250,000	120,000	198,000	121,000	198,000
Variation from base case									
200 MW new	30	48,000	95,000	51,000	102,000	49,000	81,000	50,000	83,000
200 MW existing	25	50,000	99,000	53,000	106,000	51,000	83,000	51,000	86,000
200 MW existing	20	50,000	99,000	53,000	106,000	51,000	83,000	51,000	86,000
200 MW existing	15	50,000	99,000	53,000	106,000	51,000	83,000	51,000	86,000
500 MW existing	25	119,000	237,000	128,000	256,000	123,000	202,000	123,000	207,000
500 MW existing	20	119,000	237,000	128,000	256,000	123,000	202,000	123,000	207,000
500 MW existing	15	119,000	237,000	128,000	256,000	123,000	202,000	123,000	207,000
1500 MW new	30	348,000	695,000	375,000	750,000	361,000	593,000	363,000	609,000
1500 MW existing	25	355,000	710,000	384,000	767,000	369,000	606,000	371,000	623,000
1500 MW existing	20	355,000	710,000	384,000	767,000	369,000	606,000	371,000	623,000
1500 MW existing	15	355,000	710,000	384,000	767,000	369,000	606,000	371,000	623,000
12% ash in coal	30	96,000	191,000	103,000	206,000	99,000	163,000	100,000	167,000
20% ash in coal	30	139,000	277,000	136,000	272,700	144,000	236,000	145,000	243,000
2% S in coal	30	81,000	161,000	87,000	174,000	85,000	137,000	84,000	141,000
5% S in coal	30	151,000	301,000	163,000	325,000	157,000	257,000	157,000	264,000
200 MW, no flyash	30	25,000	50,000	34,000	68,000	26,000	59,000	26,000	44,000
500 MW, no flyash	30	62,000	123,000	83,000	166,000	64,000	144,000	64,000	107,000
1500 MW, no flyash	30	185,000	369,000	249,500	497,000	192,000	430,000	192,000	323,000
5 mi to disposal	30	116,000	232,000	125,000	250,000	120,000	198,000	120,000	198,000
10 mi to disposal	30	116,000	232,000	125,000	250,000	120,000	198,000	120,000	198,000
Fixation additive amount - variation 1	30	-	-	123,000	246,500	119,000	196,000	136,00	267,000
Fixation additive amount - variation 2	30	-	-	129,000	257,000	122,000	199,000	137,000	232,000
Intermediate ponding and truck to landfill	30	-	-	125,000	250,000	-	-	-	-
Transport by truck to disposal area	30	-	-	-	-	-	-	121,000	198,000
Lime scrubbing process	30	101,000	202,000	109,000	218,000	105,000	172,000	105,000	177,000
Clarify (35% solids) and pump 1 mi	30	116,000	232,000	-	-	-	-	-	-
Clarify (35% solids) and pump 5 mi	30	116,000	232,000	-	-	-	-	-	-
Clarify (35% solids) and pump 10 mi	30	116,000	232,000	-	-	-	-	-	-
Clarify, filter (60% solids) and truck 1 mi	30	116,000	193,000	-	-	-	-	-	-
Clarify, filter (60% solids) and truck 5 mi	30	116,000	193,000	-	-	-	-	-	-
Clarify, filter (60% solids) and truck 10 mi	30	116,000	193,000	-	-	-	-	-	-
200 MW, constrained pond acreage (50% of optimum)	30	48,000	95,000	51,000	102,000	-	-	-	-
200 MW, constrained pond acreage (75% of optimum)	30	48,000	95,000	51,000	102,000	-	-	-	-
Constrained pond acreage (50% of optimum)	30	116,000	232,000	125,000	250,000	-	-	-	-
Constrained pond acreage (75% of optimum)	30	166,000	232,000	125,000	250,000	-	-	-	-
1500 MW, constrained pond acreage (50% of optimum)	30	347,000	695,000	375,000	750,000	-	-	-	-
1500 MW, constrained pond acreage (75% of optimum)	30	347,000	695,000	375,000	750,000	-	-	-	-
Pond settled density (40% solids)	30	93,000	232,000	-	-	-	-	-	-
Pond settled density (60% solids)	30	139,000	232,000	-	-	-	-	-	-
Unlined pond	30	116,000	232,000	-	-	-	-	-	-
Synthetic pond lining ($1.50/yd^2)	30	116,000	232,000	-	-	-	-	-	-
Synthetic pond lining ($2.50/yd^2)	30	116,000	232,000	-	-	-	-	-	-
Synthetic pond lining ($3.50/yd^2)	30	116,000	232,000	-	-	-	-	-	-
Synthetic pond lining ($4.50/yd^2)	30	116,000	232,000	-	-	-	-	-	-

a. Base untreated case: direct ponding in clay-lined pond, pump 1 mi from scrubber facilities, slurry to pond - 15% solids; settled slurry in pond - 50% solids.

b. Base Dravo case: ponding in clay-lined pond; pump 1 mi from scrubber facilities; 50% solids settled density in pond; treated with Calcilox (7% of dry sludge) and Thiosorbic lime (1% of dry sludge).

c. Base IUCS case: landfill disposal of 60% solids material; 1 mi to landfill from scrubber facilities; trucks used for transport of treated sludge; treated with lime (4% of dry sludge).

d. Base Chemfix case: landfill disposal of 60% solids material; 1 mi to landfill from scrubber facilities; pipeline used for transport of thickener underflow to disposal and treatment area, treated with Portland cement (7% of dry sludge) and sodium silicate (2% of dry sludge).

e. New 500-MW plant; 30-yr life; coal analysis (by wt): 3.5% S (dry basis), 16% ash; SO_2 and flyash removed together to meet NSPS; limestone process with 1.5 stoichiometry based on SO_2 removed.

TABLE 13. MATERIAL BALANCE - UNTREATED PROCESS

	Description of stream			
	Spent slurry to pond feed tank	Spent slurry to pond	Settled slurry	Recycle water
Rate, lb/hr	772,000	772,000	232,000	540,000
Rate, gpm	1,404	1,404	320	1,081
Specific gravity	1.10	1.10	1.45	1.00
% solids (undissolved)	15	15	50	0

Major Equipment

As stated earlier, very few items of equipment are needed for this disposal option. Table 14 lists the equipment used for direct ponding of sludge produced by the base 500-MW plant.

TABLE 14. UNTREATED DISPOSAL - BASE CASE

EQUIPMENT LIST

Item	No.	Description
Tank, pond feed	1	63,000 gal, field erected, 21 ft dia, 26 ft high, vertical with open top, carbon steel, 1/4 in. neoprene lined
Agitator	1	15 hp, neoprene lined
Pump, pond feed	3	1,404 gpm, 1.28 sp. gr., 300-ft head, neoprene lined, with 125-hp motor
Pump, recycle pond water	2	1,081 gpm, 200-ft head, multistage turbine, cast iron bowl, stainless steel impellers with 100-hp motor

Field Equipment

The additional items of cost other than major process equipment are piping, electrical equipment, instrumentation, excavation and site preparation, transport lines, buildings, services, pond construction, landfill, and roads and railroads. The methods of estimation of their costs are described below.

Piping--

Carbon steel pipe and gate valves are used for all water lines. For slurry lines, stainless steel pipe is used for lines less than 3-in. diameter, whereas for all larger size lines, rubber-lined carbon steel piping is used. Stainless steel strainers are used for pipes less than 4-in. diameter and rubber-lined strainers are used for 4-in.-diameter and larger pipes.

Foundations and Structural--

Concrete foundations for each equipment item are fixed according to equipment sizes. Foundations for the structure are estimated on the basis of the weight and size of the structure.

Structural estimates are based on the arrangement and types of equipment. The quantity of structure for each disposal process depends upon raw material usage, tank volumes, dewatering requirements, etc.

Electrical--

The electrical cost is divided into four sections: (1) cost of feeder cables from the power plant transformer yard to the sludge disposal system, (2) transformer costs for each area, (3) costs of power supply from area field modules to individual motors, and (4) motor control costs between remote control center, field equipment location, and individual motors. Total connected motor horsepower is calculated for use in establishing costs for feeder cables and transformers. Costs for power supplies and motor controls are based on individual motor sizes and the number of connected motors. A typical layout is assumed for the disposal system in reference to the power plant transformer yard, remote control center, and other areas. Pumps for return of supernate from disposal ponds 5 and 10 mi from the power plants are not controlled from the power plant-sludge disposal system. Additional labor is needed to monitor these pumps.

Instrumentation--

Instrumentation costs are based on (1) fixed costs for instruments which do not change in size and cost with equipment and size variations and (2) variable costs for instruments which increase in size and cost as equipment and pipe sizes increase. Each of these costs may be dependent upon the number of pumps, feeders, mixers, conveyors, dryers, thickeners, etc. Costs are included for control valves, graphic and panelboards, annunciators, air dryers and piping, and instrument cable and wiring systems.

Excavation and Site Preparation--

The excavation and site preparation requirements depend upon the number of items and the type and size of equipment. Estimates are based on the number of cubic yd of material that is moved in each case. The cost of excavation for underground pipelines for transport of sludge to the disposal area represents a major portion of excavation cost for those cases requiring pipeline.

Transport Lines--

The pipelines used for transporting slurry to a disposal pond and for returning water to the scrubber facility are called transport lines. For the base case a 1-mi, carbon steel, rubber-lined, 12-in. line is used. These lines are underground (2 ft) and a spare line is included. The recycle water line for the base case is a 10-in., carbon steel unlined pipe, and no spare line is costed. The size of the lines for the variations of untreated cases varies from 8 to 18 in. for the pond feed lines and from 6 to 16 in. for the recycle water lines.

Buildings--

Additional buildings are not needed for the direct ponding untreated cases. All pumps are controlled from the scrubber facility. A building is needed for the untreated cases that require dewatering of sludge to 60% solids for landfill disposal. Rotary drum filters which are used for dewatering are located inside a building. The controls for this equipment are housed near the equipment and a control building is included in costs.

Services--

The cost of services for each case was estimated to be 1-1/2% of direct investment cost. This cost includes vehicles, maintenance and instrument shop equipment, laboratories, lockers, offices, restrooms, storage area, parking area, walkways, landscaping, fencing, and security allocated to the sludge disposal area by the power plant.

Pond Construction--

A computer program was used to calculate optimum pond dimensions and costs for each case. The total pond depth for the base case pond is 21.2 ft, with an excavation depth of 3.0 ft. The pond covers 407 acres, is assumed to be built on relatively level land, and is square. All ponds are lined with 1 ft of clay except those variations where another liner type is specified so that the effect of liner cost on overall pond cost can be estimated. Figure 1 shows typical construction diagrams for the perimeter and diverter dikes of the disposal pond. The length of the diverter dike is assumed to be three-fourths of the length of one side of the perimeter.

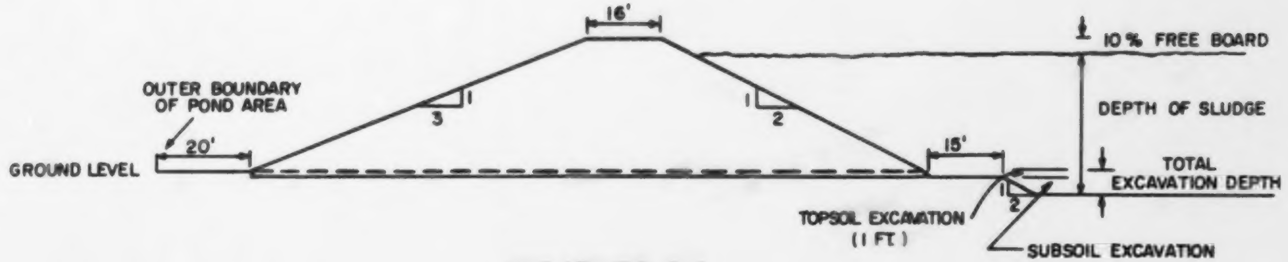
Roads and Railroads--

Railroads are not needed for untreated sludge disposal systems. All untreated cases are estimated to require 6600 ft of roadway. This requirement is for access to the disposal area, to pumps, and to other required equipment with a service vehicle. In the case of landfill disposal, roads are needed for trucks used in the transport of sludge to the disposal area. The cost of roads is held constant for all cases including disposal at a site of 5 or 10 mi from the scrubber facility. For these cases it is assumed that public roads can be used, with a minimum requirement of plant access roads (6600 ft).

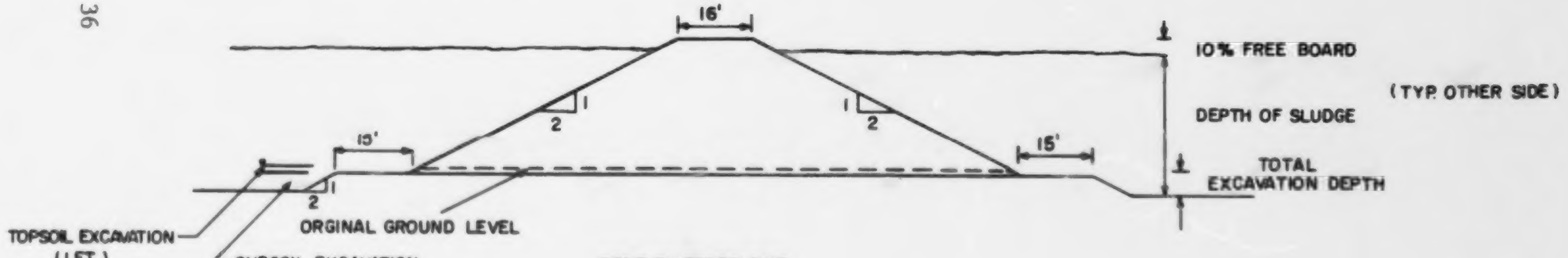
Case Variations

The base case premises discussed in Design and Economic Premises of this report apply to all untreated sludge disposal cases. The following variations from the base case are considered in this evaluation.

1. The distance to the disposal pond is 1 mi for the base case. Five- and 10-mi distances are also considered. The items changing are the sludge transport lines, pond feed pumps, and pond recycle water pumps.


16'
10% FREE BOARD
OUTER BOUNDARY OF POND AREA
1
3
1
2
DEPTH OF SLUDGE
20'
15'
GROUND LEVEL
TOTAL EXCAVATION DEPTH
1
2
TOPSOIL EXCAVATION (1 FT.)
SUBSOIL EXCAVATION

POND PERIMETER DIKE


16'
10% FREE BOARD
(TYP. OTHER SIDE)
1
2
1
2
DEPTH OF SLUDGE
15'
15'
TOTAL EXCAVATION DEPTH
1
2
ORGINAL GROUND LEVEL
TOPSOIL EXCAVATION (1 FT.)
SUBSOIL EXCAVATION

POND DIVERTER DIKE

Figure 1. Limestone slurry process dike construction diagram.

2. The base case disposal pond is lined with 12 in. of clay. Special cases are considered for an unlined pond and four types of synthetic linings. The pond cost is significantly affected by the type of liner used.

3. The settled density of the ponded sludge is 50% solids for the base case. Cases for 40 and 60% solids settled density are considered. This variation affects the pond construction cost, recycle water pump size, and land requirement.

4. The gravity thickener can be used to dewater sludge to 35% solids. Special cases are considered for the pumping of this partially dewatered sludge to disposal ponds located 1, 5, and 10 mi from the scrubber facility. By dewatering before transporting, the cost of pipelines and pond feed pumps is reduced.

5. If gravity thickeners and rotary drum filters are used, the 15% solids slurry can be dewatered to form materials containing 35 and 60% solids respectively. The latter material can be handled by truck for landfill disposal. Those variations include cases for landfill disposal of dewatered sludge at disposal sites located 1, 5, and 10 mi from the scrubber facility.

6. The base case is a 500-MW power plant. Two variations--new 200- and 1500-MW plants--are also considered.

7. Disposal systems are evaluated for 5-, 10-, and 15-yr-old existing 200-, 500-, and 1500-MW power plants.

8. The coal analysis was varied as follows:

Component	Base case condition	Variations from base case
S, %	3.5	2, 5
Ash, %	16	12, 20

9. Three cases were considered for 200-, 500-, and 1500-MW power plants equipped with an ESP upstream of the scrubber system. The sludge disposal system was evaluated for handling only the calcium solids sludge.

10. One case was evaluated for the direct ponding of a 10% slurry taken from a lime scrubber system with 1.1 stoichiometry. The total amount of SO_2 removed was the same as the base case; however, the amount of excess lime is less than that of excess limestone in the base case. Although the amount of SO_2 removed is the same as the base case, the size of equipment needed for handling and transport of sludge is larger than that used in the base case (10% slurry vs 15% slurry).

TREATED SLUDGE

Sludge generated by FGD systems that use lime or limestone as the primary sorbent for SO_2 is usually a thixotropic, fluid material containing 85-90% water. The material can be dewatered by using gravity thickeners and various types of filters to yield a more stable product for disposal (19). However, the sludge can easily become fluid again if subjected to vibration or stress or if water is added. The dewatered sludge also lacks, in many instances, the desirable chemical and physical properties which would prevent the contamination of surface and ground water.

The treatment of sludge with fixation additives, such as lime, cement, flyash, etc., can result in the formation of a claylike or an earthlike material which is structurally and environmentally more acceptable than untreated sludge. In all stabilization-fixation processes the sludge is solidified by adding materials that result in pozzolanic or other cementitious reactions. These reactions take place between various components of the sludge (alumina and silica in the flyash, lime, limestone, sulfates, and sulfites) and the additives. Chemical fixation of the FGD sludge produces a material that may ultimately be more desirable because of the following improvements in structural properties (2).

- Lower permeability, porosity, and leachability
- Improved mechanical properties that enable easier handling
- Decreased tendency for softening or reslurry with addition of water
- Higher bulk density
- Increased structural strength

The chemical properties of sludges are also improved by fixation. Pozzolanic or cementitious reactions result in the formation of complex and less soluble compounds that tie up water and trace elements. The potential for ground or surface water pollution is thereby reduced. A number of fixation processes are available for utility use and among those are the Dravo, IUCS, and Chemfix processes which are evaluated in this report. These three processes in which different chemical reactions and mechanisms occur produce stable and more environmentally acceptable materials than untreated sludge.

DRAVO PROCESS

The product for disposal from the Dravo fixation process is a slurry containing 35% solids which is pumped to a disposal pond for curing. This slurry settles to form a material containing about 50% solids in the disposal pond and begins to solidify. The curing-solidification step requires 15-30 days depending upon the sludge composition and additive rates. Slurry underflow from the scrubber facility is pumped to an agitated tank which has a capacity of about 8 hr of underflow. The slurry (15% solids) from this tank is fed to a thickener where the solids content is increased to 35%. Thickener overflow water is returned to the scrubber loop for use in slurry makeup.

Underflow material is pumped to a tank for mixing with Dravo process additives, Thiosorbic lime, and Calcilox. The mix tank is agitated and has an 8-hr capacity.

Lime is received at the waste disposal facility in a covered rail car, unloaded, and conveyed to a bucket elevator for transfer to storage silos (30 days' capacity). The lime is in pebble form when received and must be slaked before use. Lime is transferred from the storage silos via weigh feeders to an 8-hr storage hopper that feeds a lime slaker. The lime slurry from the slaker is pumped to an agitated storage tank (8-hr capacity). The slurry is pumped to the mix tank for blending with sludge.

Calcilox is received by either rail or truck and pneumatically conveyed to 30-day storage silos. Calcilox is transferred from the storage silos via weigh feeders to feed hoppers (8-hr capacity) for the mix tank.

The treated sludge is pumped from the mix tank to the disposal pond. The reactions between the sludge and additives begin immediately after mixing, but the sludge properties are not significantly changed for several days. Supernatant water from the disposal pond is returned to the scrubber facility for reuse. The flow diagram and material balance for this process are shown in Figure 2 .

Major Equipment (33)

Table 15 lists all items of process equipment included in the Dravo system, with a brief description of each equipment item for the base case. A control diagram and layout drawings for the base case of the Dravo process are shown in Figures 3-5.

Field Equipment

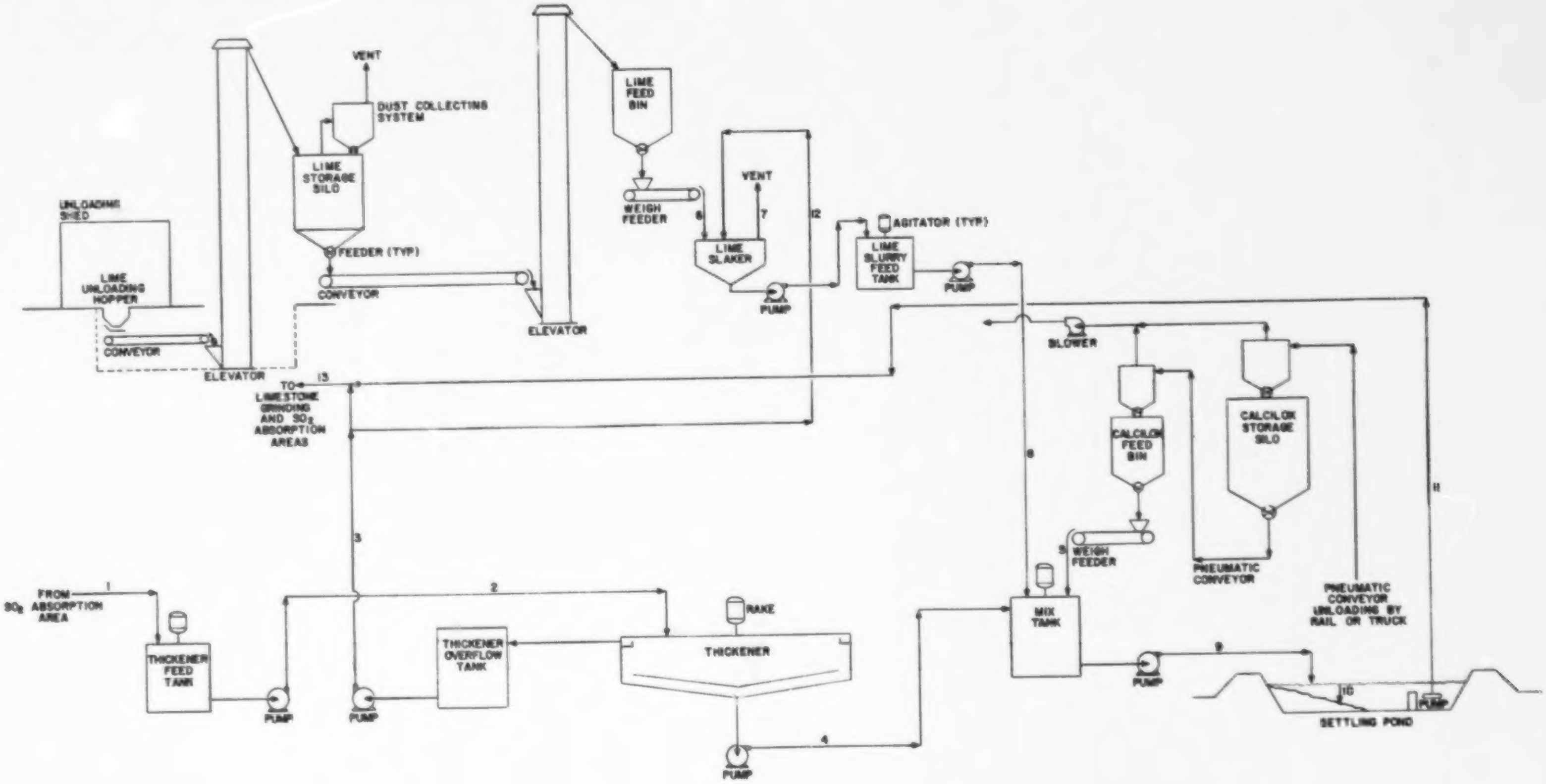
The discussion that follows is similar to that of the untreated system. Each area of cost other than process equipment is discussed here.

Piping--

See piping description for the untreated system.

Foundations and Structural--

See foundations and structural description for the untreated system.


VENT
DUST COLLECTING SYSTEM
LIME STORAGE SILO
FEEDER (TYP)
UNLOADING SHED
LIME UNLOADING HOPPER
CONVEYOR
ELEVATOR
CONVEYOR
ELEVATOR
LIME FEED BIN
WEIGH FEEDER
6
VENT
7
LIME SLAKER
PUMP
12
AGITATOR (TYP)
LIME SLURRY FEED TANK
PUMP
13
TO LIMESTONE GRINDING AND SO2 ABSORPTION AREAS
BLOWER
8
CALCILOX FEED BIN
CALCILOX STORAGE SILO
11
5
WEIGH FEEDER
PNEUMATIC CONVEYOR
PNEUMATIC CONVEYOR UNLOADING BY RAIL OR TRUCK
3
FROM SO2 ABSORPTION AREA
1
THICKENER FEED TANK
PUMP
PUMP
2
THICKENER OVERFLOW TANK
RAKE
THICKENER
PUMP
4
MIX TANK
PUMP
9
10
PUMP
SETTLING POND

STREAM NO	1	2	3	4	5	6	7	8	9	10	11	12	13
DESCRIPTION	SLURRY TO THICKENER FEED TANK	SLURRY TO THICKENER	THICKENER OVERFLOW	UNDERFLOW TO MIX TANK	CALCILOX TO MIX TANK	LIME TO SLAKER	VENT FROM SLAKER	LIME SLURRY TO MIX TANK	USED SLURRY TO STLG POND	SETTLED USED SLURRY	RECYCLE POND WATER	RECYCLE WATER TO SLAKER	RECYCLE WATER TO SYSTEM
LB/HR	772k	772k	441k	331k	8108	1158	67	7720	347k	250k	97k	6562	53k
GPM	1404	1404	883	517				14	533	329	193	13.1	1063
SP GR	1.10	1.10		1.28				1.09	1.30	1.52			
UNDSLVD SLDS %	15	15		33				15	38	50			

Notes:

Calculations based on

1. 150% limestone stoichiometry based on SO_2 removed
2. 90% of S in coal evolved as SO_2
3. 3.5% S and 16% ash coal
4. Flyash removed with SO_2
5. SO_2 removed to meet NSPS
6. 15% of SO_2 removed oxidized to gypsum
7. 80% of ash in coal evolved as flyash

Figure 2. Dravo Process. Flow diagram and material balance - base case.

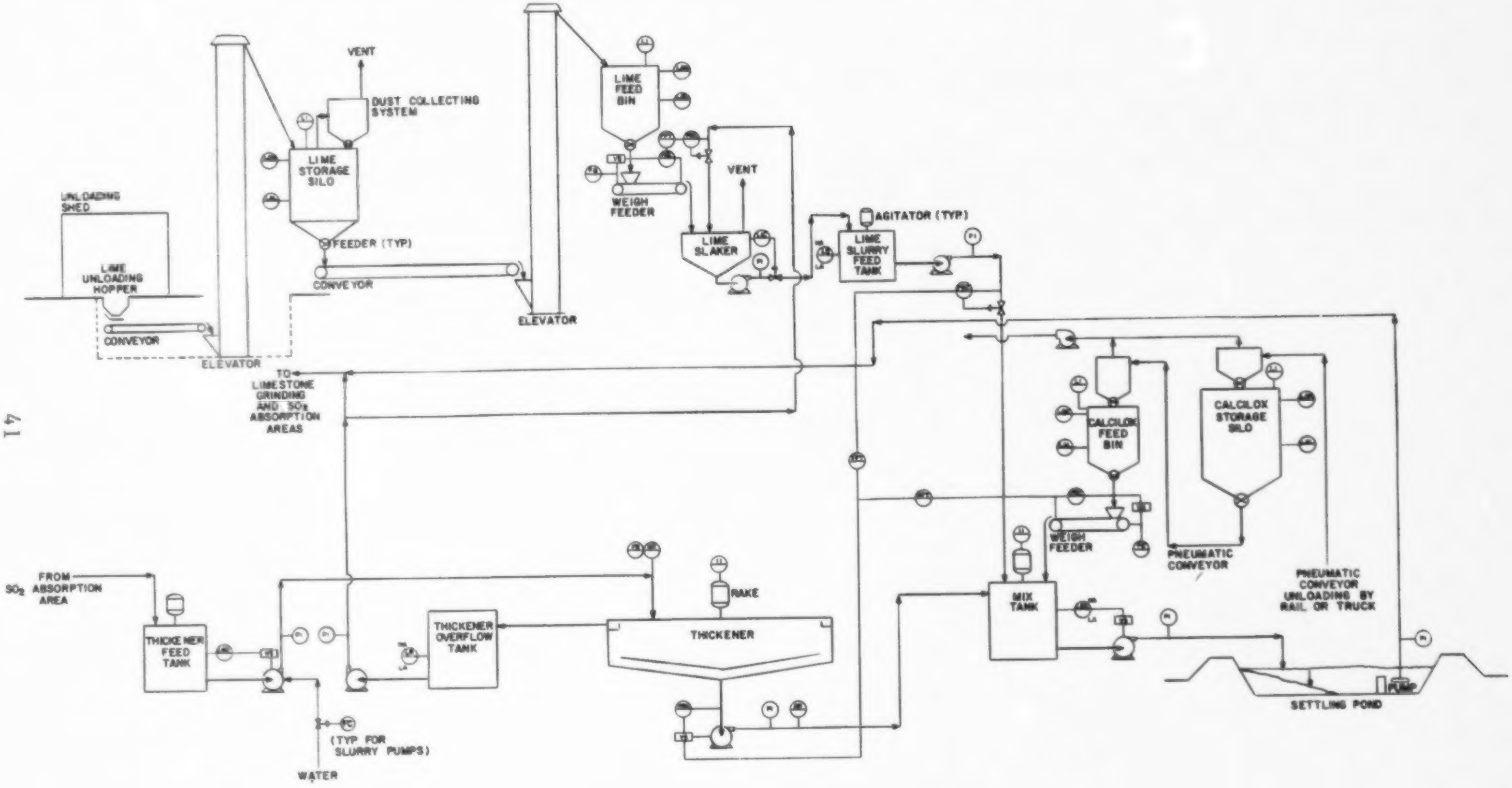

UNLOADING SHED
LIME UNLOADING HOPPER
CONVEYOR
ELEVATOR
VENT
DUST COLLECTING SYSTEM
LIME STORAGE SILO
FEEDER (TYP)
CONVEYOR
ELEVATOR
LIME FEED BIN
WEIGH FEEDER
VENT
LIME SLAKER
AGITATOR (TYP)
LIME SLURRY FEED TANK
TO LIMESTONE GRINDING AND SO_2 ABSORPTION AREAS
CALCILOX FEED BIN
CALCILOX STORAGE SILO
WEIGH FEEDER
PNEUMATIC CONVEYOR
PNEUMATIC CONVEYOR UNLOADING BY RAIL OR TRUCK
FROM SO_2 ABSORPTION AREA
THICKENER FEED TANK
(TYP FOR SLURRY PUMPS)
WATER
THICKENER OVERFLOW TANK
RAKE
THICKENER
MIX TANK
PUMP
SETTLING POND

Figure 3. Dravo process. Control diagram - base case.

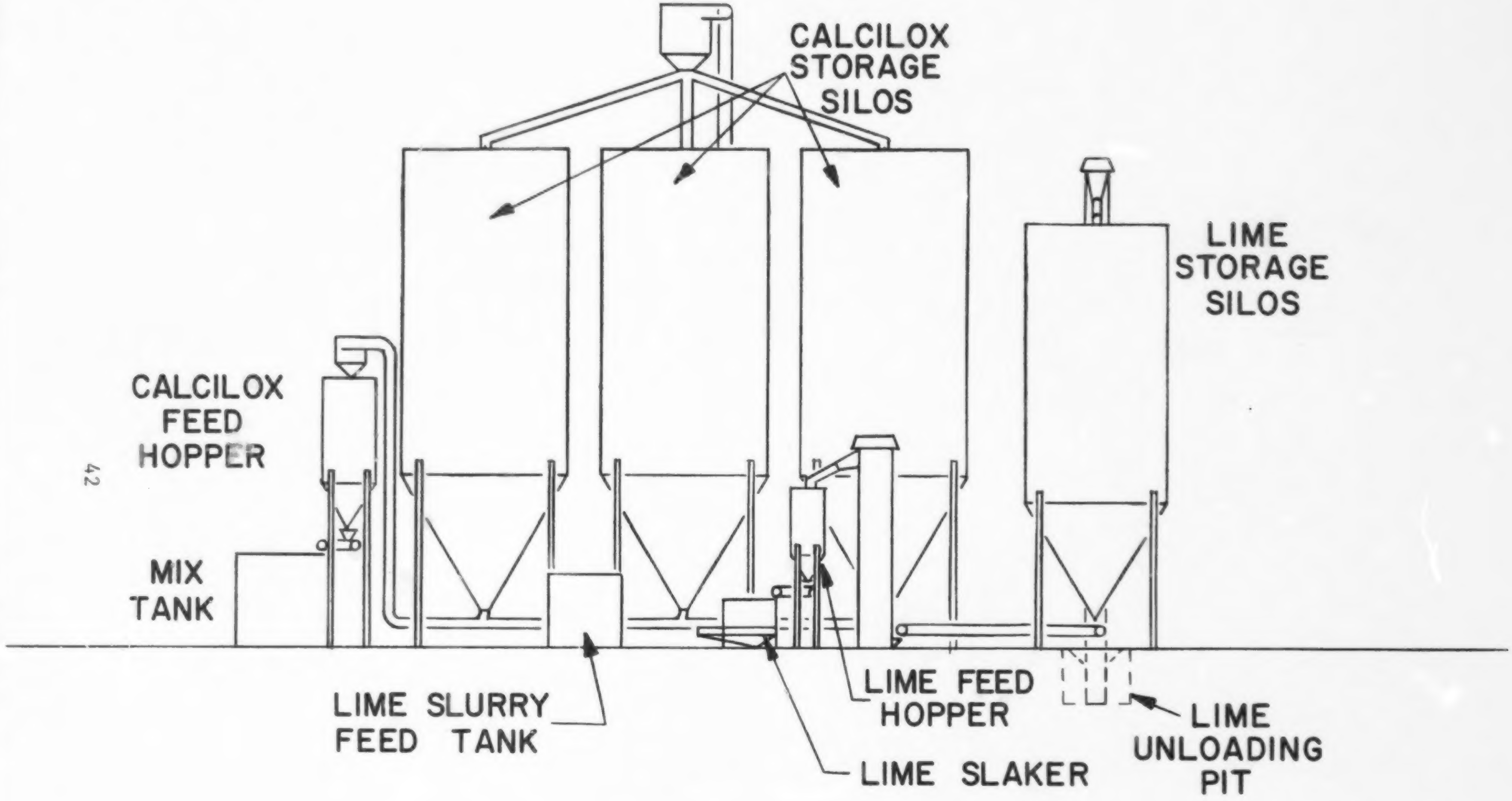

CALCILOX
STORAGE
SILOS
LIME
STORAGE
SILOS
CALCILOX
FEED
HOPPER
MIX
TANK
LIME SLURRY
FEED TANK
LIME FEED
HOPPER
LIME SLAKER
LIME
UNLOADING
PIT

Figure 4. Dravo process. Elevation - base case.

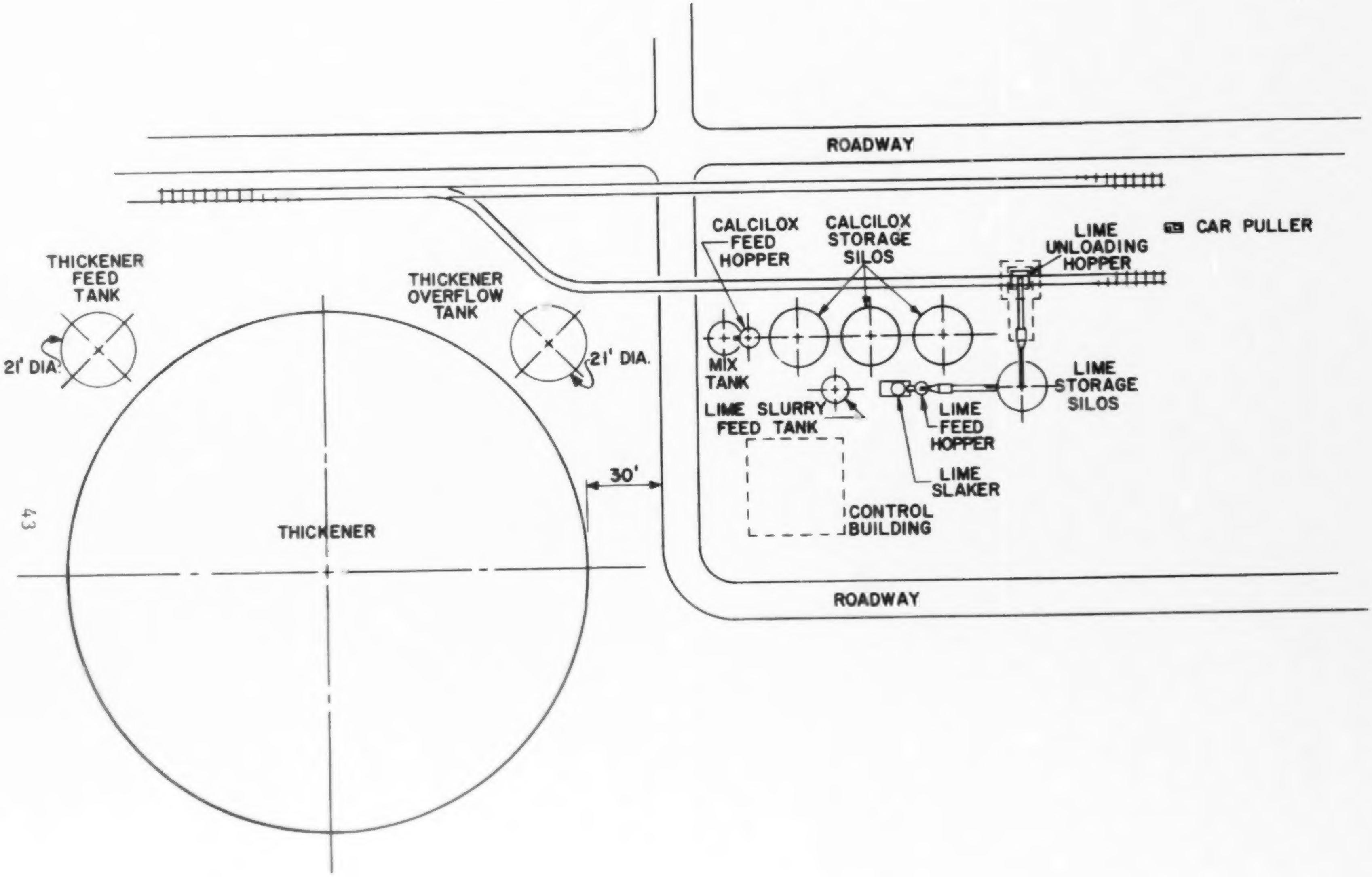

ROADWAY
CALCILOX FEED HOPPER
CALCILOX STORAGE SILOS
LIME UNLOADING HOPPER
CAR PULLER
THICKENER FEED TANK
THICKENER OVERFLOW TANK
21' DIA.
21' DIA.
MIX TANK
LIME SLURRY FEED TANK
LIME FEED HOPPER
LIME STORAGE SILOS
LIME SLAKER
30'
CONTROL BUILDING
THICKENER
ROADWAY

Figure 5, Dravo process. Overall plot plan - base case.

TABLE 15. DRAVO PROCESS - BASE CASE EQUIPMENT LIST

Item	No.	Description
1. Lime unloading hopper	1	8 ft 4 in. side, 2 ft 4 in. bottom, 3 ft deep, carbon steel
2. Lime unloading feeder	1	24 in. wide x 42 in. long pan, 2-1/2-hp vibrator, carbon steel
3. Lime unloading conveyor	1	100 ft/min, 24-in. belt, 20 ft long, 1-hp motor, carbon steel
4. Sump pump, tunnel under unloading conveyor	1	5 gpm, 10-ft head, neoprene lined, carbon steel, 1/2-hp motor
5. Bucket elevator, lime storage silo	1	45 tons/hr, 80 ft high, carbon steel, 7-1/2-hp motor
6. Silo, lime storage	1	21 ft dia, 42 ft high, with top and 60-degree cone bottom, carbon steel, 30-day storage capacity
7. Dust collecting system, lime silo and unloading system	1	12,000 ft^3/min inertial separator; dust hopper, fan, and 60-hp motor, carbon steel
8. Feeder discharge, lime storage silo	1	Rotary air lock, 8 in. dia x 8 in. long, carbon steel
9. Vibrator, lime storage silo	8	Electromechanical rotary vibrators, 1-hp motor
10. Conveyor	1	10 tons/hr, 30 ft long, 14 in.-belt, 100 ft/min, carbon steel, 1/2-hp motor
11. Bucket elevator	1	10 tons/hr, 30 ft high, 1-hp motor, carbon steel
12. Feed bin, lime to slaker	1	5 ft dia, 10 ft high, with top and 60-degree cone bottom, carbon steel
13. Vibrator, lime feed bin	4	Electromechanical rotary vibrators, 1-hp motor
14. Feeder discharge, lime feed bin	1	Rotary air lock, 8 in. dia x 8 in. long, carbon steel

(continued)

TABLE 15 (continued)

Item	No.	Description
15. Weigh feeder, lime to slaker	1	5 ft long, 14-in. belt, carbon steel, 3/4-hp motor
16. Lime slaker	1	20 ft x 5-1/2 ft x 9 ft, 7,720 lb/hr, 15% solids slurry rate, neoprene lined, carbon steel, 10-hp agitator motor
17. Pump, slaked lime to storage	2	14 gpm, 50 ft head, centrifugal, neoprene lined, carbon steel, 3/4-hp motor
18. Tank, lime slurry	1	8-hr storage, 11 ft high, 11 ft dia, vertical, cylindrical, open top, neoprene lined, carbon steel
19. Agitator, lime slurry tank	1	Neoprene coated, 7-1/2-hp motor
20. Pump, lime slurry to mix tank	2	14 gpm, 60-ft head, centrifugal, neoprene-lined, carbon steel, 3/4-hp motor
21. Pneumatic conveying system, Calcilox	1	Complete system with blower, cyclone receiver, receiver filter, pump, motor
22. Car puller	1	15,000 lb, 500 ft, 15-hp motor
23. Storage silo, Calcilox	3	25 ft dia, 49 ft high, with top, 60-degree cone bottom, carbon steel, 30-day storage capacity
24. Vibrator, Calcilox silos	24	Electromechanical rotary vibrators, 1-hp motor
25. Discharge feeder, Calcilox storage silos	3	Rotary air lock, 8 in. dia, 8 in. long, carbon steel
26. Feed bin, Calcilox to mix tank	1	8 ft dia, 16 ft high, with top, 60-degree cone bottom, carbon steel, 8-hr storage
27. Discharge feeder, Calcilox feed bin	1	Rotary air lock, 8 in. dia, 8 in. long, carbon steel
28. Vibrator, Calcilox feed bin	4	Electromechanical rotary vibrators, 1-hp motor

(continued)

TABLE 15 (continued)

Item	No.	Description
29. Weigh feeder, Calcilox to mix tank	1	7 ft long, 26-in. belt, 4 tons/hr, 3/4-hp motor
30. Tank, thickener feed	1	21 ft dia, 26 ft high, neoprene lined, carbon steel
31. Agitator, thickener feed tank	1	Neoprene coated, 15-hp motor
32. Pump, sludge to thickener	2	75-ft head, 1,404 gpm, centrifugal, neoprene lined, 60-hp motor
33. Thickener	1	219 ft dia, 10 ft high, stainless steel or rubber-coated concrete basin, rake, and drive motor with spare
34. Pump, thickener overflow water	2	881 gpm, 75-ft head, centrifugal, neoprene lined, 30-hp motor, carbon steel
35. Tank, thickener overflow water	1	10 ft high, 18 ft dia, neoprene lined, carbon steel
36. Pump, thickener underflow	2	517 gpm, 75-ft head, centrifugal, neoprene lined, 25-hp motor
37. Sump pump, thickener pit	1	5 gpm, 10-ft head, centrifugal, neoprene lined, 1/2-hp motor
38. Mix tank	1	14 ft dia, 14 ft high, neoprene lined, carbon steel
39. Agitator, mix tank	1	Neoprene coated, 15-hp motor
40. Pump, pond feed	3	533 gpm, 300-ft head, centrifugal, neoprene lined, 75-hp motor
41. Pump, recycle water	2	195 gpm, 200-ft head, multistage turbine, 75-hp motor

Electrical--

See electrical description for the untreated system.

Instrumentation--

See instrumentation description for the untreated system.

Excavation and Site Preparation--

See excavation and site preparation description for the untreated system.

Transport Lines--

The base Dravo case (500-MW plant) requires an 8-in.-diameter, neoprene-lined, carbon steel pipe for transport of sludge to the disposal pond. The recycle water line is 4 in. in diameter and made of carbon steel. A spare line for slurry feed to the pond is included in the system design.

For the case variations pond feed line sizes vary from 6 to 16 in. in diameter and recycle water line sizes vary from 2 to 6 in. in diameter. All pipes are underground (2-ft depth).

Buildings--

A control building is needed for all Dravo cases. The same size building (40-ft wide x 40-ft long) is estimated for all cases. No buildings are needed for equipment housing.

Services--

The cost of services for the Dravo cases is estimated to be 1-1/2% of direct investment costs. The cost for services is discussed in more detail in the services discussion of the untreated disposal process.

Pond Construction--

The pond sizes were estimated using a computer program as in the cases for untreated ponding. The Dravo base case pond is 21.4 ft total depth and the excavation depth is 3.0 ft. The area covered by the pond is 414 acres. All ponds are clay lined, square, and have a divider dike.

Roads and Railroads--

Calcilox and Thiosorbic lime are received at the plant by rail. All Dravo cases are estimated to require 750 ft of track with turnouts and bumper stops for unloading raw materials received in railroad cars. A car puller for moving cars in and out of unloading area is included in equipment costs. Roads, estimated to be 8000 ft, are required for access to the disposal pond, to pumps, and to other equipment.

Case Variations

Case variations for the Dravo process are described below. All process conditions other than these variable parameters are the same as for the base case as described above.

1. The base case is a new 500-MW station with a 30-yr life. Two cases also evaluated are new 200- and 1500-MW stations with a 30-yr life.

2. Disposal systems are evaluated for existing 200-, 500-, and 1500-MW plants having remaining lives of 25, 20, and 15 yr.

3. The coal analysis variations are the same as for the untreated cases.

4. Sludge disposal systems are evaluated for 200-, 500-, and 1500-MW plants that have ESP for flyash removal. The resulting sludge for disposal contains very little flyash and therefore the total quantity of material for disposal is less than for the base cases (200-, 500-, and 1500-MW new plants). Flyash collection and disposal is not considered for these cases.

5. Two cases are considered for disposal ponds located 5 and 10 mi from the scrubber facility. Equipment requirements for these cases are identical to the base case except for pumps for transport of sludge to the disposal pond. The added distance to the disposal pond, as compared to a 1-mi location, increases the pumping requirement such that centrifugal neoprene-lined pumps cannot be used as in other cases. Large positive displacement plunger pumps are used to meet this requirement.

6. The amount of Calcilox addition for all cases, except two variations, is 7% by wt of the dry sludge solids. Two cases are evaluated for Calcilox additions of 5 and 10% of dry solids. The rate of curing is directly affected by the concentration of additive in the product mixture.

7. One Dravo case is evaluated for sludge from a new 500-MW plant (base premises) using a lime scrubber operating at a 1.1 stoichiometric mol ratio of $CaO:SO_2$ removed. The scrubber slurry contains 10% solids (15% is used for limestone cases), therefore, additional dewatering capacity is needed due to the reduced scrubber system stoichiometry; the total amount of sludge for disposal is less than that in the base case.

8. Dravo offers a design variation that yields a fixed sludge that can be landfilled. The system is very similar to the system for ponding except the material is pumped from the mix tank to a series of small curing ponds near the scrubber facility, instead of to a permanent disposal pond. The material is allowed to cure in a small pond for 2-4 wk and is then dug out with a clamshell or front-end loader for transport by truck to a landfill. The material has physical properties similar to a silty-clay soil.

IUCS PROCESS

An earthlike material that can be used for landfill disposal is produced using the IUCS sludge fixation process. This material has physical and structural properties that make it suitable for handling with belt conveyors, trucks, and typical earthmoving equipment.

Spent slurry containing 15% solids from the FGD system is pumped to an agitated storage tank (8-hr capacity). The slurry is fed to a thickener in which the solids content in the slurry is increased from 15 to 35%. Thickener overflow water is returned to the scrubber facility for reuse. Underflow is pumped to a rotary drum filter and the sludge is dewatered to form a material containing 60% solids. Filtrate is also returned to the scrubber system for reuse. The filter cake is transferred by belt conveyor to a blade-type mixer for blending with the fixation additives. The fixed material is conveyed to a small disposal pile where it is loaded with a front-end loader into a truck and subsequently hauled to a disposal site. Lime is used as the additive and is received by truck or rail at the sludge fixation facilities. Pneumatic conveyors are used for transporting the lime to storage silos (30-day storage capacity) and for transferring the additive to feed bins (8-hr capacity) above the mixers. Weigh feeders are used to meter the lime to the mixers and the standard amount of additive is 4% by wt of the dry sludge solids. A flow diagram and material balance for the IUCS base case are shown in Figure 6 .

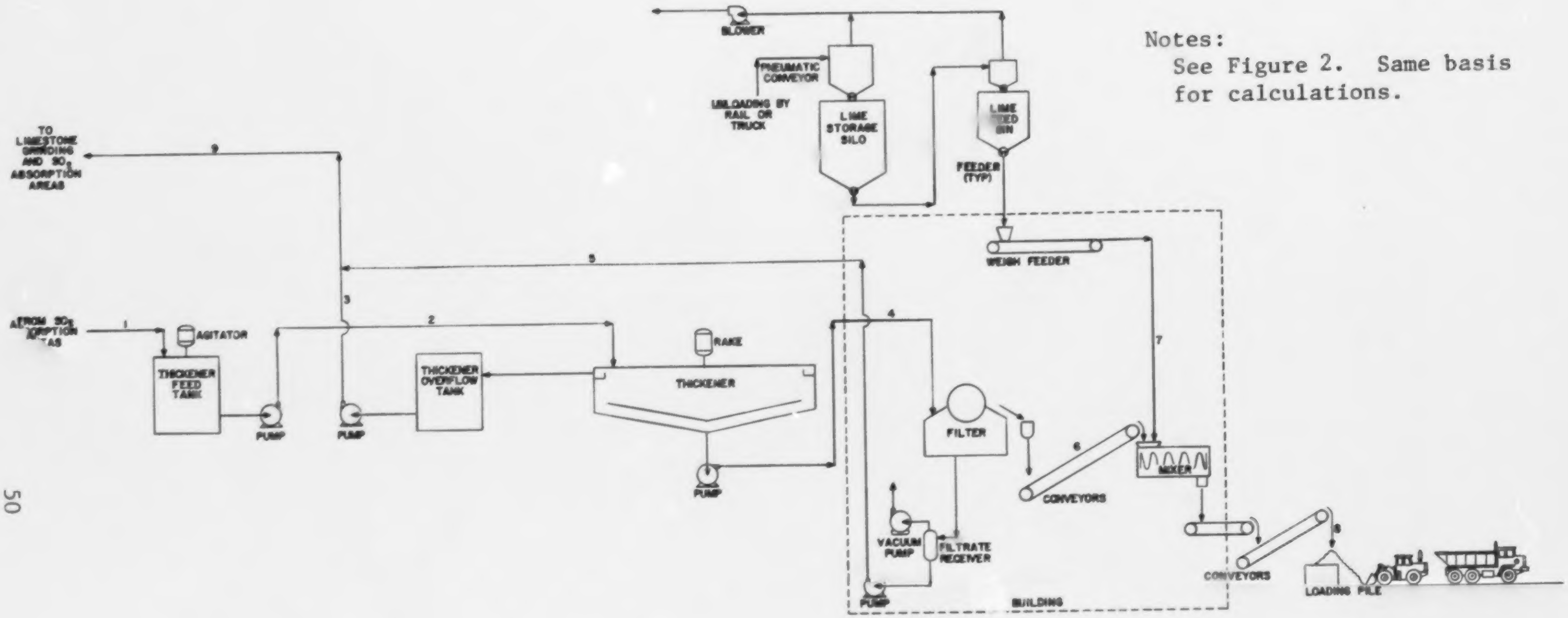
Major Equipment

All items of major equipment for the IUCS base case are included in Table 16. A control diagram for the IUCS process and layout drawings for the base case are shown in Figures 7-9.

Field Equipment

A definition of field equipment is given in the discussion of the untreated disposal systems.

Notes:
See Figure 2. Same basis for calculations.


BLOWER
PNEUMATIC CONVEYOR
UNLOADING BY RAIL OR TRUCK
LIME STORAGE SILO
LIME FEED BIN
FEEDER (TYP)
WEIGH FEEDER
TO LIMESTONE GRINDING AND SO2 ABSORPTION AREAS
9
5
3
FROM SO2 ABSORPTION AREAS
1
AGITATOR
THICKENER FEED TANK
PUMP
2
PUMP
THICKENER OVERFLOW TANK
RAKE
THICKENER
PUMP
4
FILTER
6
CONVEYORS
7
MIXER
VACUUM PUMP
FILTRATE RECEIVER
PUMP
BUILDING
CONVEYORS
8
LOADING PILE

STREAM NO.	1	2	3	4	5	6	7	8	9
DESCRIPTION	SLURRY TO THICKENER FEED TANK	SLURRY TO THICKENER	THICKENER OVERFLOW	UNDERFLOW TO FILTER	RECYCLE FILTRATE	CAKE TO MIXER	LIME TO MIXER	TREATED SLUDGE TO DISPOSAL	RECYCLE WATER TO SYSTEM
LB/HR	772k	772k	441k	331k	138k	193k	4633	198k	579k
GPM	1404	1404	883	517	276	241			1159
SP. GR.	110	110		128		160			
UNDISLVD SLDS. %	15	15		35		60			

Figure 6. IUCS process. Flow diagram and material balance - base case.

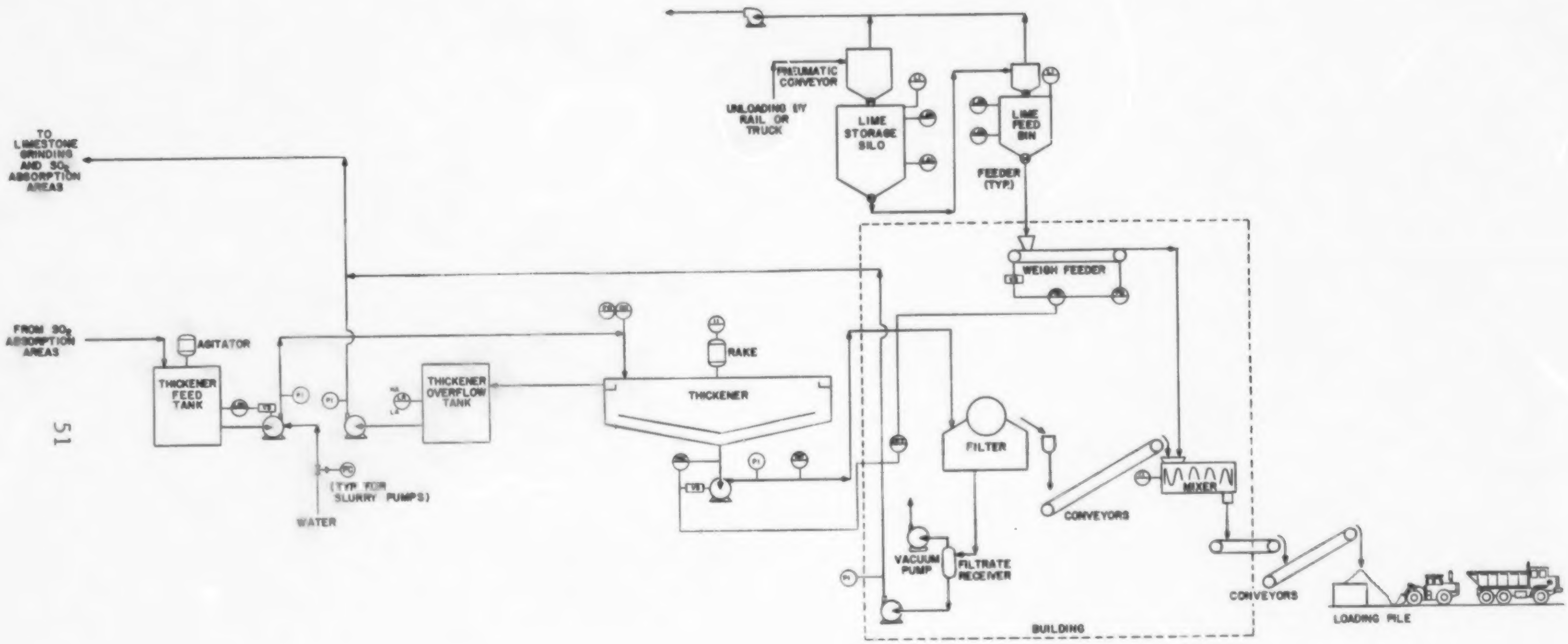

TO LIMESTONE GRINDING AND SO_2 ABSORPTION AREAS
FROM SO_2 ABSORPTION AREAS
AGITATOR
THICKENER FEED TANK
(TYP FOR SLURRY PUMPS)
WATER
THICKENER OVERFLOW TANK
RAKE
THICKENER
PNEUMATIC CONVEYOR
UNLOADING BY RAIL OR TRUCK
LIME STORAGE SILO
LIME FEED BIN
FEEDER (TYP)
WEIGH FEEDER
FILTER
VACUUM PUMP
FILTRATE RECEIVER
CONVEYORS
MIXER
CONVEYORS
BUILDING
LOADING PILE

Figure 7. IUCS process. Control diagram - base case.

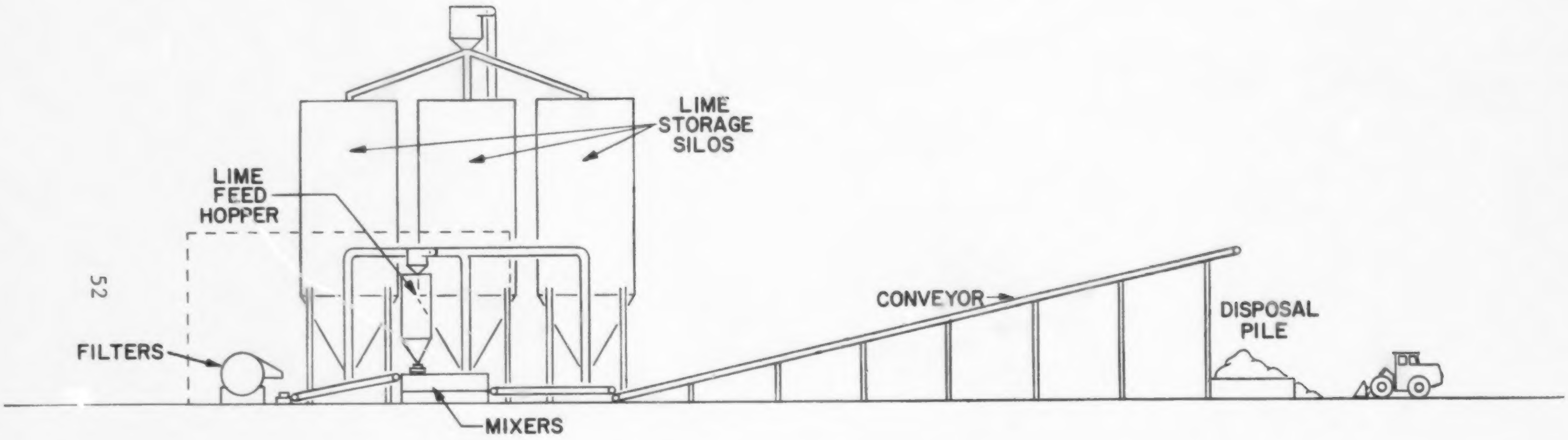

LIME
STORAGE
SILOS
LIME
FEED
HOPPER
FILTERS
MIXERS
CONVEYOR
DISPOSAL
PILE

Figure 8. IUCS process. Elevation - base case.

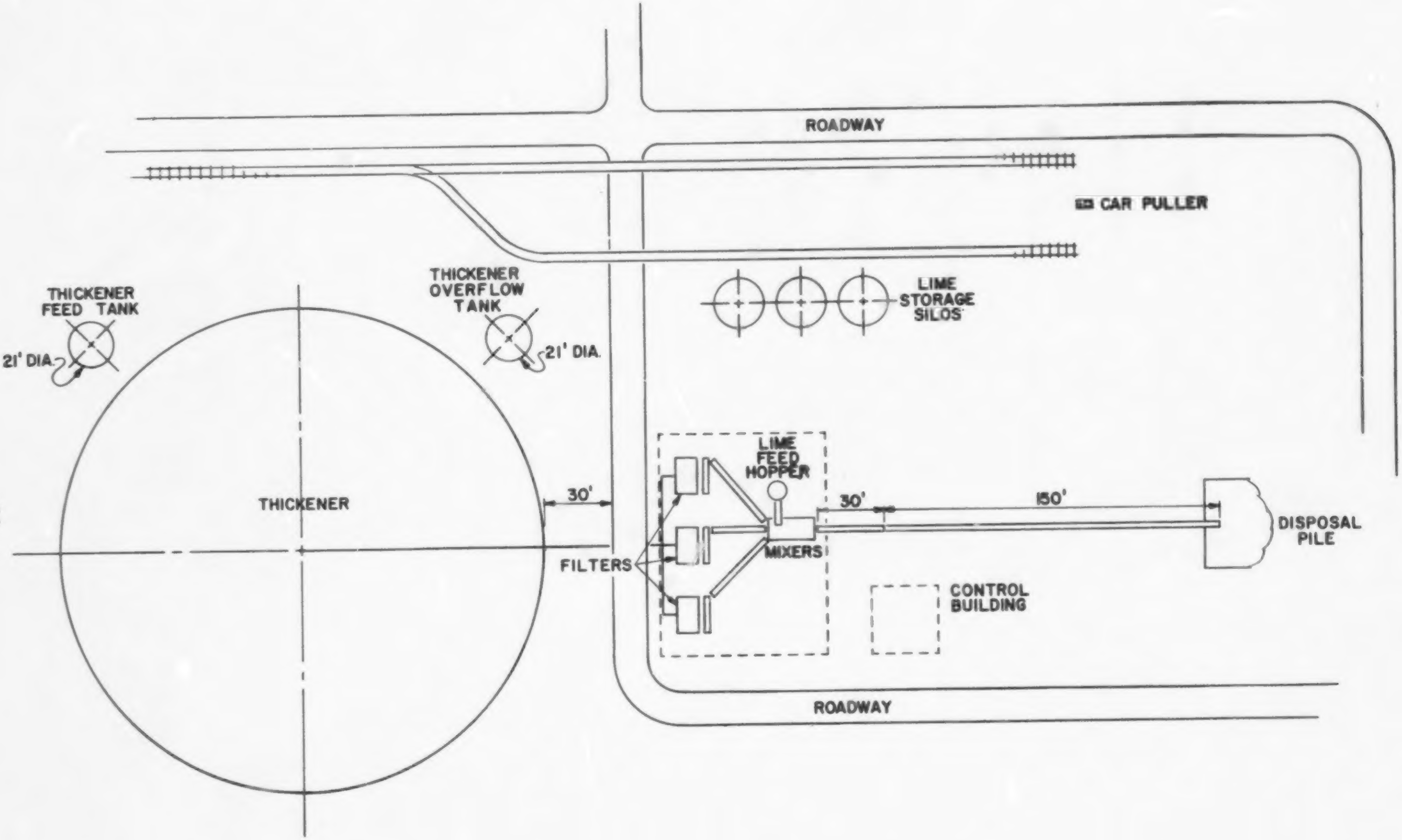

ROADWAY
CAR PULLER
THICKENER FEED TANK
21' DIA.
THICKENER OVERFLOW TANK
21' DIA.
LIME STORAGE SILOS
THICKENER
30'
LIME FEED HOPPER
30'
150'
DISPOSAL PILE
FILTERS
MIXERS
CONTROL BUILDING
ROADWAY

Figure 9. IUCS process. Overall plot plan - base case.

TABLE 16. IUCS PROCESS - BASE CASE EQUIPMENT LIST

Item	No.	Description
1. Pneumatic conveying system, lime	1	Complete system with blower, cyclone receiver, receiver filter, motor
2. Storage silo, lime	3	18,532 ft^3, 510 tons, field erected, 22.8 ft dia, 45.6 ft high, carbon steel, with top, 60-degree cone bottom
3. Feeder, discharge	3	Rotary air lock type, 4,633 lb/hr, 8 in. dia, 8 in. long, carbon steel
4. Vibrator, lime storage silo	24	Electromechanical, rotary vibrators, 1-hp motor
5. Feed bin, lime	1	618 ft^3, 7 ft dia, 15 ft high, with top, 60-degree cone bottom, carbon steel
6. Feeder, bin discharge	1	Rotary air lock type, 8 in. dia, 8 in. long, carbon steel
7. Vibrator, lime feed bin	4	Electromechanical, rotary vibrators, 1-hp motor
8. Weigh feeder, lime	1	5 ft long, 14-in. belt, 3/4-hp D.C. motor, carbon steel
9. Car puller	1	15,000 lb, 500 ft, 15-hp motor
10. Sump pump	1	5 gpm, 10-ft head, carbon steel, 1/4-hp motor
11. Tank, thickener feed	1	63,000 gal, field erected, 21 ft dia, 26 ft high, open top, four 1 ft 9 in. x 26 ft baffles offset 3-1/2 in. from wall, neoprene lined, carbon steel
12. Agitator, thickener feed tank	1	15 hp, 72-in.-dia blade, neoprene coated
13. Pump, thickener feed	2	1,500 gpm, 75-ft head, neoprene lined, 60-hp motor
14. Thickener	1	219 ft dia, stainless steel or neoprene-lined concrete basin with rake and motor with 1 spare

(continued)

TABLE 16 (continued)

Item	No.	Description
15. Tank, thickener overflow	1	26,500 gal, 16-1/2 ft dia, 16-1/2 ft high, neoprene lined, carbon steel
16. Pump, thickener overflow recycle	2	881 gpm, 75-ft head, neoprene lined, 30-hp motor
17. Pump, thickener underflow to filter	2	517 gpm, 75-ft head, neoprene lined, 25-hp motor
18. Sump pump, thickener tunnel	1	5 gpm, 10-ft head, carbon steel, 1/4-hp motor
19. Rotary drum filter	3	464 ft, 10 ft dia x 16 ft long drum, stainless steel (wetted parts), vacuum and filtrate pumps
20. Pump, filtrate recycle	2	276 gpm, 75-ft head, neoprene lined, 10-hp motor
21. Conveyor, horizontal filter	3	18 ft long, 48 tons/hr, 1/2-hp motor
22. Conveyor, sloping filter cake	3	30 ft long, 24-in. belt, 48 tons/hr, 10-hp motor
23. Mixer	1	Carbon steel, 75-hp motor
24. Conveyor, horizontal fixed cake	1	30-in. belt, 30 ft long, 99 tons/hr, 3/4-hp motor
25. Conveyor, sloping fixed cake	1	30-in. belt, 150 ft long, 99 tons/hr, 15-hp motor

Piping--
See piping description for the untreated system.

Foundations and Structural--
See foundations and structural description for the untreated system.

Electrical--
See electrical description for the untreated system.

Instrumentation--
See instrumentation description for the untreated system.

Excavation and Site Preparation--

See excavation and site preparation description for the untreated system.

Transport Lines--

There are no pipeline requirements for any of the IUCS cases.

Buildings--

Two buildings, one for a control room and another for process equipment, are needed for the IUCS facilities. The control building is 12 ft high by 40 ft by 40 ft. The equipment building is 40 ft high by 75 ft by 100 ft for the 200- and 500-MW plants and 40 ft high by 150 ft by 100 ft for the 1500-MW plants.

Services--

The cost of services is estimated to be 1-1/2% of the direct capital investment requirement. A more detailed discussion of this item is included in the discussion of the untreated process system.

Landfill--

Treated sludge is transported to a disposal site where it is placed and compacted as landfill. Land requirements for the landfill are based on the quantity of material for disposal (yd^3), assuming an average depth of 30 ft over the entire disposal site. The disposal area is cleared of vegetation and topsoil before the sludge is deposited. The clearing operation is gradual, based on the current land usage rate and eventually the entire site is covered. The landfill is covered with topsoil and can be recovered with vegetation after the filling operation is complete. The filled area is designed so that runoff rainwater or streams are diverted around the site as much as possible. The site is also contoured and sloped to prevent as much seepage as possible from rainfall. Drainage from the site is captured in a small holding pond for analysis and treatment (if needed) before release to local streams.

Earthmoving Equipment--

Fixed sludge is moved by belt conveyor from the IUCS facility to a product pile. Wheeled loaders are used to transfer the fixed sludge from the pile to a dump truck that hauls the sludge to the landfill disposal site. The fixed material is placed and compacted in the landfill using typical landfill equipment (motor grader, bulldozer, and towed roller). The base case is estimated to require two wheeled-loaders, three dump trucks, one grader, one bulldozer, and one towed roller. The number of pieces of equipment and their sizes depend on the sludge production rate and varies for the disposal alternatives considered.

Roads and Railroads--

The requirements are the same as for all treated process cases and are discussed in the Roads and Railroads section for the Dravo systems.

Case Variations

Variations from the base case are as follows:

1. Two cases for new 200- and 1500-MW power stations are considered.

2. Disposal systems are evaluated for existing 200-, 500-, and 1500-MW plants having remaining lives of 25, 20, and 15 yr.

3. Coal analysis variations are the same as for the untreated cases.

4. An IUCS system was evaluated for 200-, 500-, and 1500-MW plants that are equipped with ESP for flyash removal. In all other cases flyash is removed in the scrubber system and is part of the slurry underflow from the scrubber facility for disposal. The IUCS process requires flyash for fixation. For these cases where flyash is not included in the scrubber underflow to the IUCS facility, a provision is made for adding flyash to the sludge prior to disposal. Dry flyash from the ESP is pneumatically conveyed to storage silos near the IUCS facility. After dewatering with the thickener and rotary drum filters, as in all cases, the sludge is conveyed to a mixer for mixing with the dry flyash as well as the IUCS additive. The amount of flyash to be added is 4% by wt of the total dry solids in the sludge. The size of dewatering equipment is reduced for this system, but the facilities for flyash handling are extra requirements as compared to other processes.

5. The rate and extent of fixation can be varied by varying the amount of fixation additive used. Cases for an additive amount of 3% (base is 4%) and 5% by wt of the total dry solids in the sludge are evaluated.

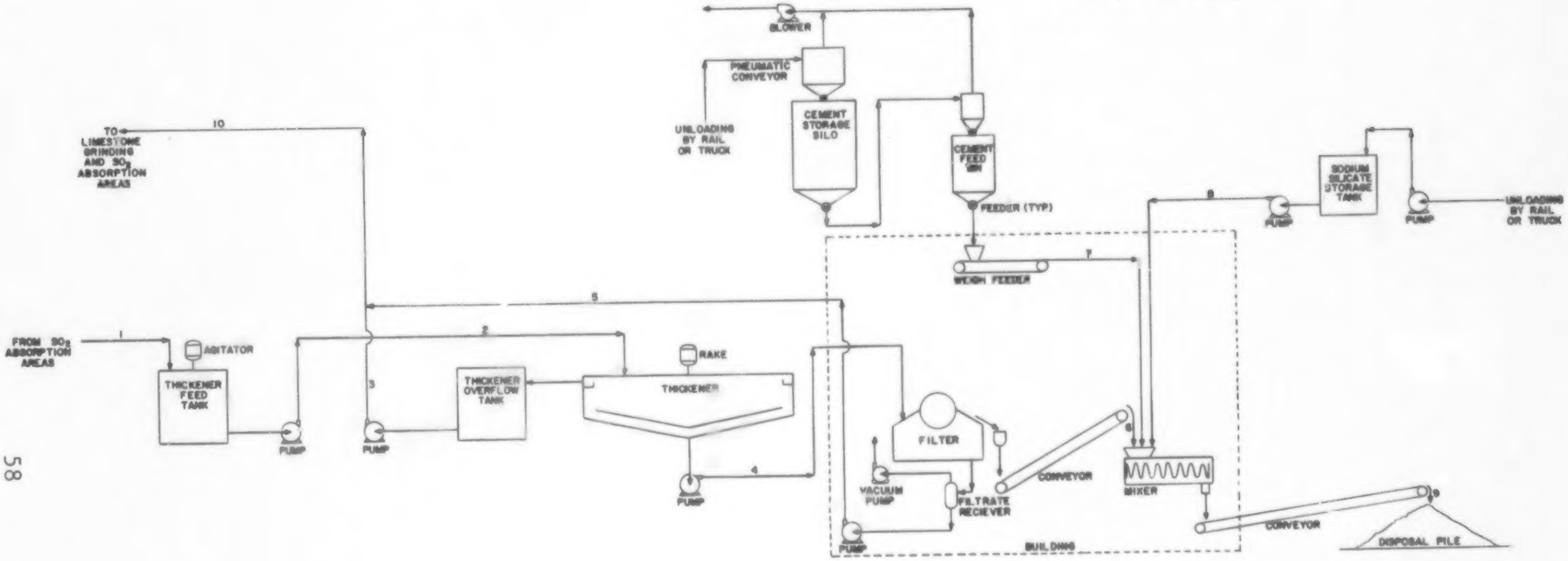
6. The evaluation is made of one IUCS disposal system for sludge from a new 500-MW plant using a lime slurry scrubber operating at a stoichiometry of 10% excess CaO. The scrubber underflow to the fixation facility contains 10% solids.

CHEMFIX PROCESS

The system for sludge fixation with the Chemfix process is very similar to the IUCS process. The product of stabilization is a soillike material that is suitable for landfill. Physical and structural properties are similar to typical soil and the fixed sludge is suitable for handling with belt conveyors, loaders, and earthmoving equipment.

A flow diagram and material balance for the Chemfix base case are shown in Figure 10. Scrubber system underflow slurry (15% solids) is pumped to an 8-hr-capacity thickener feed tank. The solids content of the sludge is increased in the thickener from 15 to 35%. Overflow water from the thickener is recycled to the scrubber system for reuse. The thickener underflow is pumped to rotary drum filters for dewatering to form a cake containing 60% solids. The dewatered sludge is transferred by belt conveyor to a blade-type mixer where Chemfix additives are blended with the sludge. Product from the mixer is transferred by belt conveyor to an earthmoving vehicle (scraper) for transport to the landfill area.

Notes:
See Figure 2. Same basis for calculations.


BLOWER
PNEUMATIC CONVEYOR
UNLOADING BY RAIL OR TRUCK
CEMENT STORAGE SILO
CEMENT FEED BIN
FEEDER (TYP)
WEIGH FEEDER
SODIUM SILICATE STORAGE TANK
PUMP
UNLOADING BY RAIL OR TRUCK
TO LIMESTONE GRINDING AND SO_2 ABSORPTION AREAS
10
FROM SO_2 ABSORPTION AREAS
1
AGITATOR
THICKENER FEED TANK
PUMP
2
3
PUMP
THICKENER OVERFLOW TANK
RAKE
THICKENER
PUMP
4
5
FILTER
VACUUM PUMP
FILTRATE RECIEVER
PUMP
CONVEYOR
6
7
8
MIXER
CONVEYOR
DISPOSAL PILE
BUILDING

STREAM NO.	1	2	3	4	5	6	7	8	9	10
DESCRIPTION	SLURRY TO THICKENER FEED TANK	SLURRY TO THICKENER	THICKENER OVERFLOW	UNDERFLOW TO FILTER	RECYCLE FILTRATE	CAKE TO MIXER	CEMENT TO MIXER	SODIUM SILICATE TO MIX TANK	TREATED SLUDGE TO DISPOSAL	RECYCLE WATER TO SYSTEM
LB/HR	772k	772k	448k	336k	136k	193k	8000	2102	203k	579k
GPM	1404	1404	883	517	276	241		30		1159
SP GR	1.10	1.10		1.26		1.60		1.40		
UNDSLVD SLDS %	15	15		35		60		38		

Figure 10. Chemfix process. Flow diagram and material balance - base case.

The fixation additives are Portland cement and sodium silicate. These materials are received in either truck or rail cars and transferred to 30-day storage facilities. Portland cement is transferred with a pneumatic conveying system to storage silos and subsequently to a feed bin (8-hr capacity) for the mixing equipment. Sodium silicate (liquid) is pumped from the unloading area to a storage tank and is metered from this tank into the sludge during mixing. The base case amount of Portland cement and sodium silicate to be added is 7% and 2% by wt, respectively, of dry solids in sludge.

The thickener is located near the scrubber facility, but the remainder of the Chemfix facilities are located at the disposal site. Pipelines are used to transport the underflow from the thickener to the remaining treatment facilities 1 mi from the scrubber area. Trucks are not required for sludge transport; however, earthmoving equipment is needed to carry the treated material to the landfill from the fixation facility.

Major Equipment

Major process equipment items are listed in Table 17. A brief description of each item is given. A control diagram and base case layout drawings for the Chemfix system are shown in Figures 11-13.

Field Equipment

A definition of field equipment is given in the discussion of the untreated disposal system.

Piping--

See piping description for the untreated system.

TABLE 17. CHEMFIX PROCESS - BASE CASE EQUIPMENT LIST

Item	No.	Description
1. Pump, sodium silicate unloading	2	50 gpm, 75-ft head, rubber lined, 3-hp motor
2. Tank, sodium silicate storage	1	129,600 gal, 28 ft dia, 28 ft high, carbon steel, rubber lined with top and flat bottom
3. Pump, sodium silicate to mixer	2	3 gpm, 75-ft head, rubber lined, 1/2-hp motor
4. Pneumatic conveying system, concrete	1	49 tons/hr, 150 ft long, 8 in. carbon steel lined
5. Silo, cement storage	4	22,154 ft^3/silo, 242 ft dia, 48.4 ft high, carbon steel with top and cone bottom

TABLE 17 (continued)

Item	No.	Description
6. Feeder, cement storage silo discharge	4	Rotary air lock type, 9 in. dia x 9 in. long, carbon steel
7. Vibrator, cement storage silo	32	Electromechanical, rotary vibrators, 1-hp motor
8. Feed bin, cement	1	985 ft^3, 8.6 ft dia, 17.2 ft high, carbon steel with top and cone bottom
9. Feeder, cement feed bin discharge	1	Rotary air lock type, 9 in. dia x 9 in. long, carbon steel
10. Weigh feeder, cement bin to mixer	1	4 tons/hr, 14-in. belt, 5.6 ft long, carbon steel
11. Vibrator, cement bin	4	Electromechanical, rotary vibrators, 1-hp motor
12. Car puller	1	15,000 lb, 500 ft, 15-hp motor
13. Sump pump	1	5 gpm, 10-ft head, 1/4-hp motor, carbon steel
14. Tank, thickener feed	1	63,000 gal, 21 ft dia, 26 ft high, open top, carbon steel, field erected, rubber lined with four 1 ft 9 in. x 26 ft baffles offset 3-1/2 in. from wall
15. Agitator, thickener feed tank	1	15 hp, rubber lined
16. Pump, thickener feed	2	1,500 gpm, 75-ft head, rubber lined, 60-hp motor
17. Thickener	1	219 ft dia, stainless steel or rubber coated, concrete basin with rake and motor (1 spare)
18. Tank, thickener overflow	1	26,500 gal, 16-1/2 ft dia, 16-1/2 ft high carbon steel with flat bottom
19. Pump, thickener overflow recycle	2	881 gpm, 75-ft head, rubber lined, 30-hp motor
20. Pump, thickener underflow	3	517 gpm, 300-ft head, rubber lined, 125-hp motor

TABLE 17 (continued)

Item	No.	Description
21. Rotary drum filter	3	464 ft^2 surface area, 10 ft dia, 16-ft long drum, stainless steel wetted parts, vacuum and receiver pumps included
22. Pump, filtrate recycle	2	276 gpm, 200-ft head, rubber lined, 30-hp motor
23. Conveyor, horizontal cake	3	48 tons/hr, 30-in. belt, 18 ft long, 100 ft/min, 1/2-hp motor
24. Conveyor, sloping cake	3	48 tons/hr, 30-in. belt, 30 ft long, 100 ft/min, 3-hp motor
25. Mixer	1	36 ft dia, 40-hp motor, 102 tons/hr
26. Conveyor, sloping to disposal	1	500 ft long, 30-in. belt, 98 tons/hr, 100 ft/min, 20-hp motor

Foundations and Structural--

See foundations and structural description for the untreated system.

Electrical--

See electrical description for the untreated system.

Instrumentation--

See instrumentation description for the untreated system.

Excavation and Site Preparation--

See excavation and site preparation description for the untreated system.

Transport Lines--

Pipelines are needed to transport sludge from the thickener to the remainder of the Chemfix treatment facilities at the disposal site. Carbon steel, neoprene-lined, 8-in.-dia, 1-mi-long pipes are used. One line is required for routine use and a second line is included as a spare. A 6-in. carbon steel line is needed for returning filtrate from the rotary drum filters to the scrubber facility. All lines are underground.

Buildings--

The building requirements are the same for Chemfix as for IUCS. All cases are estimated to require a control building and an equipment building. The sizes of these buildings are given in the discussion of the IUCS building requirements.

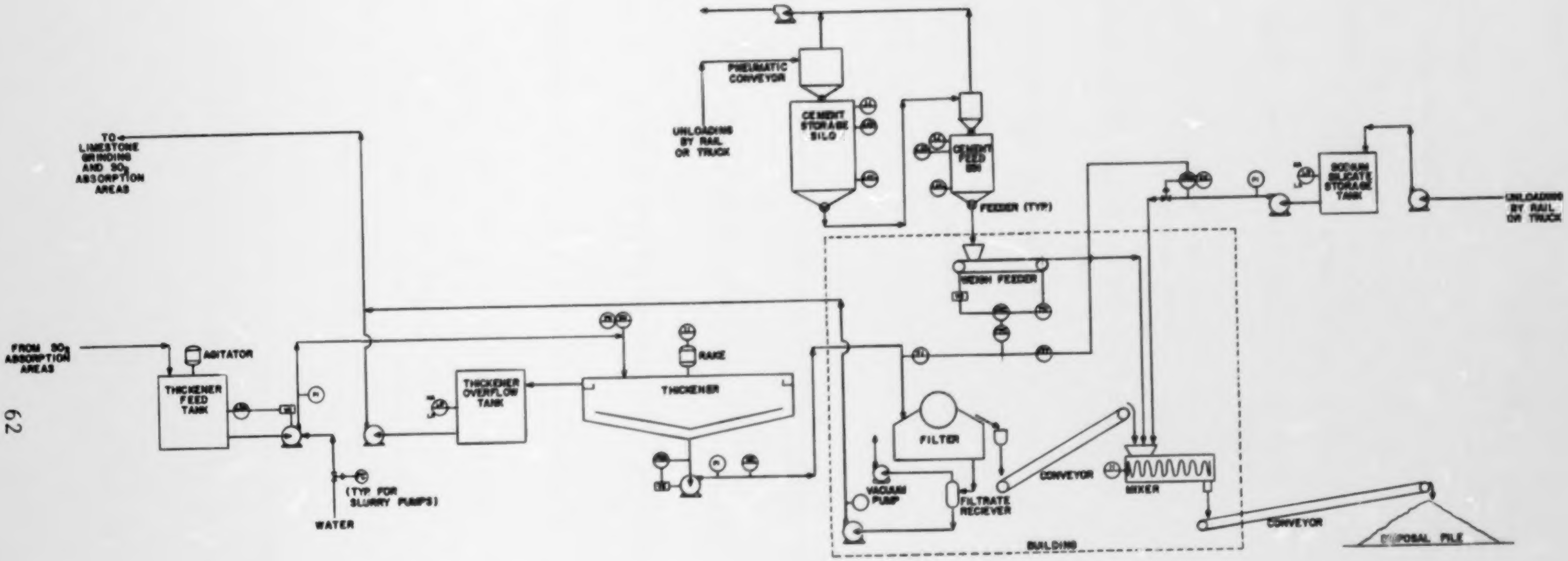

TO LIMESTONE GRINDING AND SO_2 ABSORPTION AREAS
FROM SO_2 ABSORPTION AREAS
AGITATOR
THICKENER FEED TANK
(TYP FOR SLURRY PUMPS)
WATER
THICKENER OVERFLOW TANK
RAKE
THICKENER
PNEUMATIC CONVEYOR
UNLOADING BY RAIL OR TRUCK
CEMENT STORAGE SILO
CEMENT FEED BIN
FEEDER (TYP)
WEIGH FEEDER
FILTER
VACUUM PUMP
FILTRATE RECIEVER
CONVEYOR
MIXER
BUILDING
CONVEYOR
DISPOSAL PILE
SODIUM SILICATE STORAGE TANK
UNLOADING BY RAIL OR TRUCK

Figure 11. Chemfix process. Control diagram - base case.

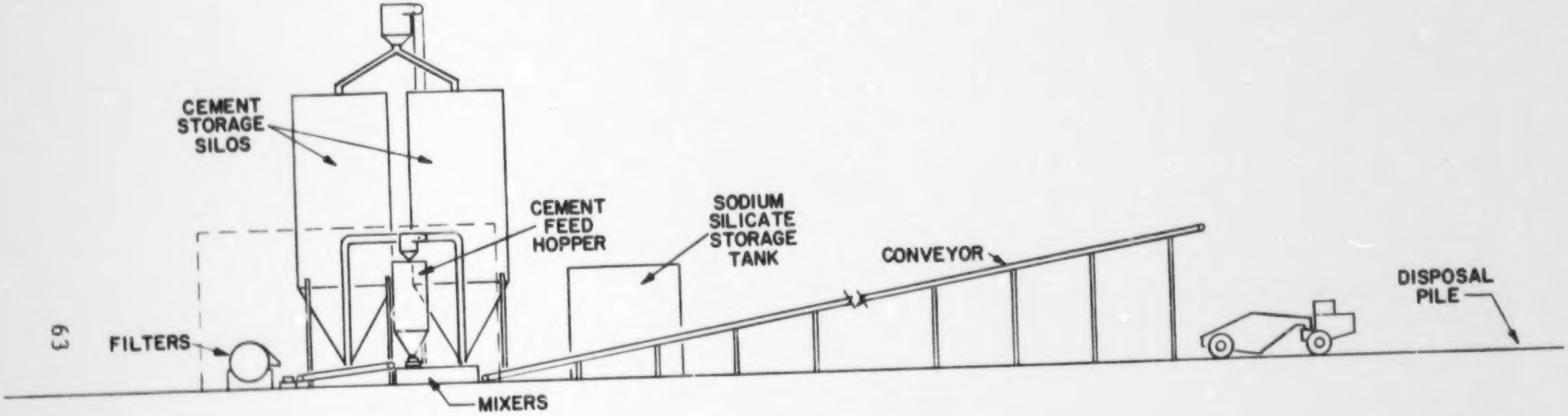

CEMENT STORAGE SILOS
CEMENT FEED HOPPER
SODIUM SILICATE STORAGE TANK
CONVEYOR
DISPOSAL PILE
FILTERS
MIXERS

Figure 12. Chemfix process. Elevation - base case.

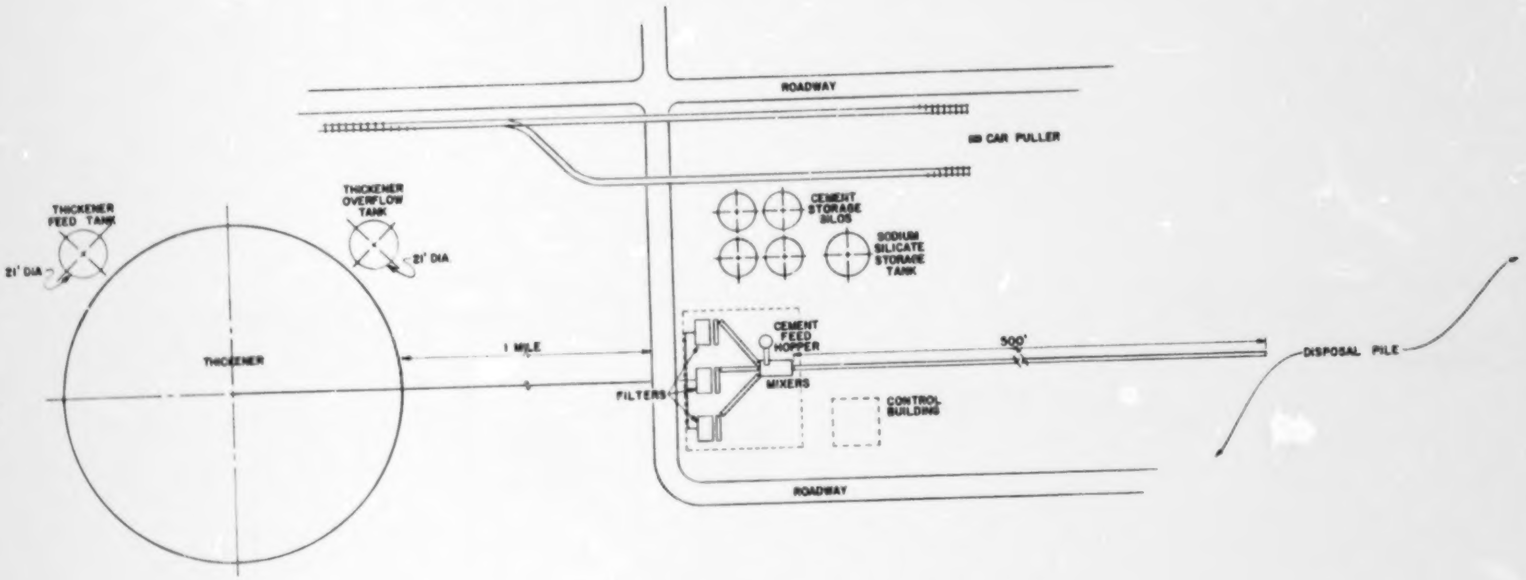

THICKENER FEED TANK
21' DIA
THICKENER
THICKENER OVERFLOW TANK
21' DIA
1 MILE
ROADWAY
CAR PULLER
CEMENT STORAGE SILOS
SODIUM SILICATE STORAGE TANK
CEMENT FEED HOPPER
FILTERS
MIXERS
CONTROL BUILDING
500'
DISPOSAL PILE
ROADWAY

Figure 13. Chemfix process. Overall plot plan - base case.

Services--

The estimate of capital needed for services is 1-1/2% of direct capital investment. A description of this requirement is included in the untreated process system estimate.

Landfill--

See landfill for IUCS case.

Earthmoving Equipment--

The Chemfix fixation facilities are located on the disposal site. Therefore, trucks are not required to transport fixed sludge from the treatment facility to a disposal site a mile away. The landfill for the 500-MW base Chemfix case is estimated to cover 198 acres. Earthmoving equipment is needed for placement of fixed sludge. Scrapers are used for transferring sludge from the treatment facility to the landfill area. Graders, bulldozers, and rollers are needed for placement of the material. The base case is estimated to require two scrapers, one bulldozer, one grader, and one towed roller.

Roads and Railroads--

The requirements are the same for all treated process cases and are discussed in the Roads and Railroads section for the Dravo systems.

Case Variations

The variations from the base case are as follows:

1. The first variation from the base is the method for transfer of material to the disposal area. The facilities for sludge treatment are adjacent to the scrubber system facilities and 1-mi sludge transport lines are not required. After the untreated dewatered sludge is mixed with fixation additives, it is transferred by belt conveyor to a small disposal pile. Wheeled loaders are used to fill trucks from this small disposal pile and the sludge is hauled 1 mi to a landfill for placement and compaction.

2. Systems for new 200- and 1500-MW plants are evaluated.

3. Evaluations are made for 200-, 500-, and 1500-MW plants having remaining lives of 25, 20, and 15 yr.

4. Coal analysis variations are the same as for the untreated system.

5. Three disposal systems are estimated for 200-, 500-, and 1500-MW power plants equipped with ESP for flyash removal. The cost of flyash collection and disposal is not considered for these variations.

6. Two cases are evaluated for disposal systems that use additive amounts other than the amount for the base case. Portland cement and sodium silicate rates are increased and percent solids in the dewatered sludge is increased in the systems evaluated for these case variations. In both cases large facilities are required for handling fixation additives

and the requirement for dewatering equipment (rotary drum filters) is reduced. Estimates are made for sludge containing 50 and 55% solids. Sodium silicate amounts are increased to 9 and 6% of the sludge solids amount respectively. Portland cement rates are also increased to 22 and 12%, respectively, for these two case variations. Curing-fixation time requirements and final product characteristics are assumed to be unchanged.

7. One Chemfix disposal system is estimated for treatment of sludge from lime scrubber operating at a stoichiometry of 10% excess CaO. Scrubber underflow to the Chemfix facility contains 10% solids.

ECONOMIC EVALUATION AND COMPARISON

Capital investment and revenue requirements were estimated for 121 cases of the four primary sludge disposal alternatives. Detailed estimates for each are included in Appendix A. These cases and the bases for the cost estimates have been described in previous sections of this report (Design and Economic Premises, Systems Estimated, and Process Background and Description).

The capital investment estimates are based on: (1) cost information obtained from engineering contracting, processing, and equipment companies; (2) information and data already available within TVA; and (3) specific cost-equipment-size relationships used for calculating indirect capital costs obtained from reliable literature sources (28-32). All capital cost estimates are projected to 1979.

The revenue requirement estimates are based on: (1) raw material costs obtained from companies currently marketing these materials; (2) current labor and supervison rates; (3) purchased power costs, and (4) currently acceptable indirect costs from reliable literature sources and current industry practice. All revenue requirement estimates are projected to 1980.

CAPITAL INVESTMENT

The capital investment of 121 cases estimated for the four primary disposal alternatives are discussed in this section. To produce results that are comparable and suitable for economic evaluation, a standard format and procedure for estimating each process was used.

Results are presented in summary tables and graphs so that comparisons between processes can be readily made.

Estimating Procedure

For each of the case variations estimated, a material balance and flowsheet were prepared. This information served as a basis for compiling an equipment list. Equipment lists for base cases are included in the Systems Estimated. Flow rates, residence times, and storage capacities were used to estimate the size of each item of process equipment. Major process equipment costs were derived from either budgetary estimates obtained from vendors or actual cost for similar equipment purchased by TVA. The costs of minor equipment were estimated using authoritative publications on equipment estimating.

As explained earlier in the section Design and Economic Premises, the projected capital investment estimates correspond to a midwestern plant location and a 3-yr construction schedule beginning mid-1977, ending mid-1980. The expected midpoint of project expenditures is mid-1979. Chemical Engineering indices are used to project current cost estimates to 1979. These indices are shown in Table 6 of the Design and Economic Premises section.

Other direct investment costs include piping, foundations and structural, electrical, excavation, roads, railroads, instrumentation buildings, services, transport lines, earthmoving equipment, and services. The details of these items are discussed in the section Systems Estimated.

The sum of costs for these items and cost of process equipment represents the direct investment requirement. Each item in the direct investment includes the combined cost of labor for fabrication and installation and the cost of materials.

Indirect investment costs are added to direct investment costs to yield the total fixed investment cost. Indirect cost items are: (1) engineering design and supervision, (2) A&E contractor expense, (3) construction expense, (4) contractor fees, (5) contingency, (6) allowance for startup and modification, and (7) interest during construction. Each of these is described in the section Design and Economic Premises.

Two other capital expense items are combined with the subtotals for direct and indirect investment to obtain the total capital investment for each case. These items are land cost and working capital.

Results

Capital Investment for Declining-Load Operating Profile--

Breakdowns of the capital investment for each of the 121 cases are presented in Appendix A. Each cost summary includes direct, indirect, and other capital items that make up the total capital investment. Tables 18-21 are summaries of total capital investments for the case variations of each disposal process. The projected total investments for the base cases (500-MW new plant) range from \$24,114,000 for disposal in a lined pond following Dravo process treatment to \$10,717,000 for landfill disposal using the IUCS fixation process.

Tables 22-25 show breakdown analyses of capital investment for the four disposal alternatives for the 200-, 500-, and 1500-MW plant cases (new units with 30-yr life).

Capital Investment for Constant-Load Operating Profile--

The total capital investment for disposal systems that serve a power plant operating at a constant load over a 30-yr life is included. All other capital estimates are for plants with a declining operating profile over a 30-yr life, resulting in a total lifetime operating time of 127,500 hr. Estimates are made for 200-, 500-, and 1500-MW plants which operate at constant annual loads of 5000 and 7000 hr/yr. The total operating time for the

30-yr life of these plants is 150,000 hr and 210,000 hr, respectively, for 5,000 and 7,000 hr/yr annual operation. The pond construction and land requirements for a disposal pond or for a landfill are, therefore, much greater; hence, both direct and indirect investment requirements are affected. Table 26 summarizes these case variations for each disposal alternative.

Land Requirements--

A significant portion of the total capital investment for each of the estimates was for the purchase of land. Land costs are estimated at $3500/acre and additional expenditures ($1700/acre) are necessary for those cases involving landfill disposal. The latter expenditures are included in the revenue requirements and are the costs associated with the use of earthmoving equipment for preparing a landfill site (excavation of topsoil and vegetation), the cost of covering the compacted sludge product with sufficient soil to prevent wind and water erosion, the cost of contouring the filled area to provide maximum runoff, minimum seepage, and the cost of constructing small collection basins for runoff and seepage water before analysis (treatment if needed) and release to local streams. Table 27 is a summary of land requirements for the four disposal alternatives.

REVENUE REQUIREMENTS

Total annual, lifetime, and constant-load revenue requirements are estimated for case variations of the four disposal methods. These estimates are based on raw material costs, labor rates, capital charges, power costs, etc. A detailed explanation of these items is given in the section Economic Premises.

Cost estimates are made on the basis of regulated economics which allow the power company to earn a specified return on investment. Regulation is usually the responsibility of state or local agencies with FPC responsible for setting guidelines for accounting and rates on interstate transactions (6). The sludge disposal system cost is combined with the total power plant investment and, therefore, increases the "rate base" on which the utility is allowed to earn at the rate set by the regulatory commission. Thus, a return on equity must be included in any process evaluation under regulated economics. This "cost-of-investment money" is added to the disposal system's revenue requirements as part of capital charges.

Estimating Procedure

Annual Revenue Requirements--

Total annual revenue requirements were estimated for the 121 case variations and are presented in tabular form in Appendix A.

TABLE 18. TOTAL CAPITAL INVESTMENT SUMMARY - UNTREATED SLUDGE DISPOSAL[a]

Case	Remaining life of system, yr	Total capital investment, k$	$/kW
Base case[b]	30	17,211	34.4
Variation from base			
200 MW	30	9,800	49.0
200 MW existing	25	8,480	42.4
200 MW existing	20	6,844	34.2
200 MW existing	15	5,511	27.6
Existing plant	25	14,578	29.2
Existing plant	20	11,399	22.8
Existing plant	15	8,822	17.6
1500 MW	30	36,455	24.3
1500 MW existing	25	30,212	20.1
1500 MW existing	20	22,904	15.3
1500 MW existing	15	16,999	11.3
12% ash in coal	30	15,031	30.1
20% ash in coal	30	19,055	38.1
2% S in coal	30	13,390	26.8
5% S in coal	30	20,655	41.3
200 MW, no flyash in sludge	30	6,716	33.6
No flyash in sludge	30	11,397	22.8
1500 MW, no flyash in sludge	30	23,595	15.7
5 mi to disposal	30	26,836	53.7
10 mi to disposal	30	37,420	74.8
Pond settled density, 40% solids	30	20,070	40.1
Pond settled density, 60% solids	30	15,194	30.4
Lime scrubbing process, 1.1 stoichiometry	30	16,226	32.5
Clarify (35% solids) and pump 1 mi to pond	30	18,490	37.0
Clarify (35% solids) and pump 5 mi to pond	30	24,881	49.8
Clarify (35% solids) and pump 10 mi to pond	30	31,458	63.0
Clarify, filter (60% solids) and truck to disposal (1 mi)	30	8,294	16.6
Clarify, filter (60% solids) and truck to disposal (5 mi)	30	8,825	17.6
Clarify, filter (60% solids) and truck to disposal (10 mi)	30	9,249	18.5
200 MW constrained pond acreage (50% of optimum)	30	12,774	63.9
200 MW constrained pond acreage (75% of optimum)	30	10,203	51.0
Constrained pond acreage (50% of optimum)	30	22,676	45.3

(continued)

TABLE 18 (continued)

Case	Remaining life of system, yr	Total capital investment, k$	$/kW
Constrained pond acreage (75% of optimum)	30	17,985	36.0
1500 MW constrained pond acreage (50% of optimum)	30	48,917	32.6
1500 MW constrained pond acreage (75% of optimum)	30	38,228	25.5
Pond settled density, 40% solids	30	20,070	40.1
Pond settled density, 60% solids	30	15,194	30.4
Unlined pond	30	14,391	28.8
Synthetic pond lining ($1.50/yd^2)	30	20,994	42.0
Synthetic pond lining ($2.50/yd^2)	30	23,070	46.1
Synthetic pond lining ($3.50/yd^2)	30	24,959	50.0
Synthetic pond lining ($4.50/yd^2)	30	26,707	53.4

a. Basis
Midwest plant location; average basis for cost scaling, mid-1979.
SO_2 and flyash removed to meet New Source Performance Standards (NSPS).

b. Base case
New 500-MW plant with 30-yr life; direct ponding of 15% solids slurry in a clay-lined pond 1 mi from scrubber facilities; settled density in pond, 50% solids.

TABLE 19. TOTAL CAPITAL INVESTMENT SUMMARY - DRAVO[a]

Case	Remaining life of system, yr	Total capital investment, k$	$/kW
Base case[b]	30	24,114	48.2
Variation from base			
200 MW	30	13,942	69.7
200 MW existing	25	13,258	66.3
200 MW existing	20	11,597	58.0
200 MW existing	15	10,239	51.2
Existing plant	25	21,416	42.8
Existing plant	20	18,281	36.6
Existing plant	15	15,553	31.1
1500 MW	30	48,235	32.2
1500 MW existing	25	41,382	27.6
1500 MW existing	20	33,924	22.6
1500 MW existing	15	27,905	18.6
12% ash	30	21,446	42.9
20% ash	30	26,028	52.1
2% S	30	19,251	38.5
5% S	30	28,523	57.0
200 MW, no flyash	30	12,242	61.2
No flyash	30	19,745	39.5
1500 MW no flyash	30	38,722	25.8
5 mi to disposal	30	30,994	62.0
10 mi to disposal	30	37,765	75.5
5% Calcilox added	30	23,120	46.2
10% Calcilox added	30	25,209	50.4
Lime scrubbing process, 1.1 stoichiometry	30	21,318	42.6
Intermediate ponding and truck to landfill	30	12,670	25.3
200 MW constrained pond acreage (50% of optimum)	30	20,701	103.5
200 MW constrained pond acreage (75% of optimum)	30	17,305	86.5
Constrained pond acreage (50% of optimum)	30	37,697	75.4
Constrained pond acreage (75% of optimum)	30	31,061	62.1
1500-MW constrained pond acreage (50% of optimum)	30	80,098	53.4
1500-MW constrained pond acreage (75% of optimum)	30	64,503	43.0

a. Basis
Midwest plant location; average basis for cost scaling, mid-1979.
SO_2 and flyash removed to meet NSPS.

b. Base case
New 500-MW plant with 30-yr life; ponding of 35% solids slurry in a clay-lined pond 1 mi from scrubber facilities; settled density in pond, 50% solids; pipeline transport to disposal area; Calcilox for stabilization (7% of dry sludge).

TABLE 20. TOTAL CAPITAL INVESTMENT SUMMARY - IUCS[a]

Case	Remaining life of system, yr	Total capital investment, k$	$/kW
Base case[b]	30	10,717	21.4
Variation from base			
200 MW	30	7,193	36.0
200 MW existing	25	7,428	37.1
200 MW existing	20	7,351	36.8
200 MW existing	15	7,295	36.5
Existing plant	25	10,591	21.2
Existing plant	20	10,402	20.8
Existing plant	15	10,269	20.5
1500 MW	30	20,105	13.4
1500 MW existing	25	19,952	13.3
1500 MW existing	20	19,382	12.9
1500 MW existing	15	18,976	12.7
12% ash	30	9,345	18.7
20% ash	30	11,957	23.9
2% S	30	9,025	18.1
5% S	30	12,283	24.6
200 MW, no flyash	30	7,301	36.5
No flyash	30	9,839	19.7
1500 MW, no flyash	30	18,103	12.1
5 mi to disposal	30	11,377	22.8
10 mi to disposal	30	11,891	23.8
3% lime for stabilization	30	10,302	20.6
5% lime for stabilization	30	10,748	21.5
Lime scrubbing process, 1.1 stoichiometry	30	10,383	20.8

a. Basis
Midwest plant location; average basis for cost scaling, mid-1979. SO_2 and flyash removed to meet NSPS.

b. Base case
New 500-MW plant with 30-yr life; landfill disposal of 60% solids material 1 mi from scrubber facilities; truck transport of treated sludge to disposal area; lime for stabilization (4% of dry sludge).

TABLE 21. TOTAL CAPITAL INVESTMENT SUMMARY - CHEMFIX[a]

Case	Remaining life of system, yr	Total capital investment, k$	$/kW
Base case[b]	30	13,531	27.1
Variation from base			
200 MW	30	9,259	46.3
200 MW existing	25	9,448	47.2
200 MW existing	20	9,367	46.8
200 MW existing	15	9,311	46.5
Existing plant	25	13,400	26.8
Existing plant	20	13,204	26.4
Existing plant	15	13,077	26.2
1500 MW	30	24,104	16.1
1500 MW existing	25	23,922	15.9
1500 MW existing	20	23,337	15.6
1500 MW existing	15	22,915	15.3
12% ash	30	11,879	23.8
20% ash	30	14,192	28.4
2% S	30	11,123	22.2
5% S	30	14,854	29.7
200 MW, no flyash	30	7,767	38.8
No flyash	30	10,124	20.2
1500 MW, no flyash	30	18,313	12.2
5 mi to disposal	30	20,227	40.5
10 mi to disposal	30	26,988	54.0
Fixation additive rate No. 1	30	16,270	32.5
Fixation additive rate No. 2	30	14,757	29.5
Lime scrubbing process, 1.1 stoichiometry	30	12,431	24.9
Transport by truck to disposal area	30	11,740	23.5

a. Basis
Midwest plant location; average basis for cost scaling, mid-1979. SO_2 and flyash removed to meet NSPS.

b. Base case
New 500-MW plant with 30-yr life; landfill disposal of 60% solids material 1 mi from scrubber facilities; pipeline transport to treatment and disposal area; fixation additives - Portland cement (7% of dry sludge) and sodium silicate (2% of dry sludge).

TABLE 22. CAPITAL INVESTMENT ANALYSIS - UNTREATED PROCESS

	Investment					
	200 MW[a]		500 MW[a]		1500 MW[a]	
	k$	% of total	k$	% of total	k$	% of total
Process equipment	78	0.8	128	0.7	237	0.6
Piping and insulation	96	1.0	121	0.7	207	0.5
Transport lines	746	7.5	1,109	6.4	1,922	5.3
Foundation and structural	6	0.1	7	0.1	14	0.1
Excavation, site preparation; roads and railroads	66	0.7	73	0.4	77	0.2
Electrical	354	3.6	395	2.3	522	1.4
Instrumentation	41	0.4	53	0.3	53	0.1
Buildings	-	-	-	-	-	-
Subtotal	1,387	14.1	1,886	10.9	3,032	8.3
Services and miscellaneous	21	0.2	28	0.2	45	0.1
Subtotal excluding pond	1,408	14.3	1,914	11.1	3,077	8.4
Pond construction	3,652	37.3	7,251	42.2	16,946	46.5
Subtotal direct investment	5,060	51.6	9,165	53.3	20,023	54.9
Engineering design and supervision	262	2.7	367	2.1	587	1.6
Architect-engineering contractor expense	38	0.4	49	0.3	71	0.2
Construction expense	713	7.3	1,102	6.4	1,997	5.5
Contractor fees	329	3.3	517	3.0	936	2.6
Subtotal	6,402	65.3	11,200	65.1	23,614	64.8
Contingency	1,280	13.1	2,240	13.0	4,723	12.9
Subtotal fixed investment	7,682	78.4	13,440	78.1	28,337	77.7
Allowance for startup and modification	403	4.1	619	3.6	1,139	3.1
Interest during construction	922	9.4	1,613	9.3	3,400	9.4
Subtotal capital investment	9,007	91.9	15,672	91.0	32,876	90.2
Land	708	7.2	1,423	8.3	3,359	9.2
Working capital	85	0.9	116	0.7	220	0.6
Total capital investment	9,800	100.0	17,211	100.0	36,455	100.0

a. Basis
New plant (30-yr life), Midwest plant location, mid-1979 costs.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2 to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond disposal, 15% solids slurry, settled density - 50% solids, clay-lined, 1 mi from scrubber facilities.

TABLE 23. CAPITAL INVESTMENT ANALYSIS - DRAVO PROCESS

	Investment					
	200 MW[a]		500 MW[a]		1500 MW[a]	
	k$	% of total	k$	% of total	k$	% of total
Process equipment	1,405	10.2	2,272	9.4	4,363	9.1
Piping and insulation	179	1.3	262	1.1	424	0.9
Transport lines	451	3.2	657	2.7	978	2.0
Foundation and structural	116	0.8	313	1.3	540	1.1
Excavation, site preparation; roads and railroads	141	1.0	164	0.7	240	0.5
Electrical	795	5.7	974	4.0	1,301	2.7
Instrumentation	100	0.7	113	0.5	119	0.3
Buildings	115	0.8	115	0.5	115	0.2
Subtotal	3,302	23.7	4,870	20.2	8,081	16.8
Services and miscellaneous	50	0.3	73	0.3	121	0.2
Subtotal excluding pond	3,352	24.0	4,943	20.5	8,202	17.0
Pond construction	3,479	25.0	7,410	30.7	17,358	36.0
Subtotal direct investment	6,831	49.0	12,353	51.2	26,560	53.0
Engineering design and supervision	682	4.9	821	3.4	1,136	2.4
Architect-engineering contractor expense	144	1.0	162	0.7	207	0.4
Construction expense	1,048	7.5	1,627	6.7	2,823	5.9
Contractor fees	414	3.0	649	2.3	1,127	2.3
Subtotal	9,119	65.4	15,612	64.7	30,853	64.0
Contingency	1,824	13.1	3,122	13.0	6,171	12.8
Subtotal fixed investment	10,943	78.5	18,734	77.7	37,024	76.8
Allowance for startup and modification	746	5.4	1,132	4.7	1,967	4.1
Interest during construction	1,313	9.4	2,249	9.3	4,443	9.2
Subtotal capital investment	13,002	93.3	22,114	91.7	43,434	90.1
Land	676	4.8	1,450	6.0	3,414	7.0
Working capital	264	1.9	550	2.3	1,387	2.9
Total capital investment	13,942	100.0	24,114	100.0	48,235	100.0

a. Basis
New plant (30-yr life), Midwest plant location, mid-1979 costs.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2 to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond disposal of treated 35% solids slurry in a clay-lined pond located 1 mi from scrubber facilities, slurry settled density - 50% solids.

TABLE 24. CAPITAL INVESTMENT ANALYSIS - IUCS PROCESS

	Investment					
	200 MW[a]		500 MW[a]		1500 MW[a]	
	k$	% of total	k$	% of total	k$	% of total
Process equipment	1,520	21.1	2,551	23.7	5,050	25.1
Piping and insulation	126	1.8	176	1.6	287	1.4
Transport lines	-	-	-	-	-	-
Foundation and structural	65	0.9	136	1.3	314	1.6
Excavation, site preparation; roads and railroads	94	1.3	115	1.1	180	0.9
Electrical	430	6.0	639	6.0	1,012	5.0
Instrumentation	56	0.8	70	0.7	74	0.4
Buildings	550	7.6	550	5.1	1,004	5.0
Subtotal	2,841	39.5	4,237	39.5	7,921	39.4
Services and miscellaneous	43	0.6	64	0.6	119	0.6
Subtotal excluding trucks and equipment	2,884	40.1	4,301	40.1	8,040	40.0
Trucks and earthmoving equipment	400	5.6	581	5.4	1,057	5.2
Subtotal direct investment	3,284	45.7	4,882	45.5	9,097	45.2
Engineering design and supervision	311	4.3	392	3.7	495	2.5
Architect-engineering contractor expense	78	1.1	98	0.9	124	0.6
Construction expense	602	8.3	839	7.8	1,410	7.0
Contractor fees	237	3.3	320	3.0	514	2.6
Subtotal	4,512	62.7	6,531	60.9	11,640	57.9
Contingency	902	12.6	1,306	12.2	2,328	11.6
Subtotal fixed investment	5,414	75.3	7,837	73.1	13,968	69.5
Allowance for startup and modification	501	7.0	726	6.8	1,291	6.4
Interest during construction	650	9.0	940	8.8	1,676	8.3
Subtotal capital investment	6,565	91.3	9,503	88.7	16,935	84.2
Land	280	3.9	676	6.3	2,030	10.1
Working capital	348	4.8	538	5.0	1,140	5.7
Total capital investment	7,193	100.0	10,717	100.0	20,105	100.0

[a] Basis
New plant (30-yr life), Midwest plant location, mid-1979 costs.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2 to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Landfill disposal of 60% solids material 1 mi from scrubber facilities, trucks used for transport of treated material to disposal site.

TABLE 25. CAPITAL INVESTMENT ANALYSIS - CHEMFIX PROCESS

	Investment					
	200 MW[a]		500 MW[a]		1500 MW[a]	
	k$	% of total	k$	% of total	k$	% of total
Process equipment	1,709	18.6	2,885	21.3	5,499	22.8
Piping and insulation	173	1.9	227	1.7	367	1.5
Transport lines	487	5.3	697	5.2	1,027	4.3
Foundation and structural	77	0.8	207	1.5	394	1.6
Excavation, site preparation; roads and railroads	138	1.5	162	1.2	239	1.0
Electrical	587	6.3	853	6.3	1,274	5.3
Instrumentation	87	0.9	107	0.8	119	0.5
Buildings	550	5.9	550	4.1	1,004	4.2
Subtotal	3,808	41.2	5,690	42.1	9,923	41.2
Services and miscellaneous	57	0.6	85	0.6	149	0.6
Subtotal excluding trucks and equipment	3,865	41.8	5,775	42.7	10,072	41.8
Trucks and earthmoving equipment	423	4.6	442	3.2	789	3.3
Subtotal direct investment	4,288	46.4	6,217	45.9	10,861	45.1
Engineering design and supervision	392	4.2	472	3.5	564	2.3
Architect-engineering contractor expense	98	1.1	118	0.9	141	0.6
Construction expense	768	8.3	1,072	8.0	1,700	7.1
Contractor fees	290	3.1	385	2.8	588	2.4
Subtotal	5,836	63.1	8,264	61.1	13,854	57.5
Contingency	1,167	12.6	1,653	12.2	2,771	11.5
Subtotal fixed investment	7,003	75.7	9,917	73.3	16,625	69.0
Allowance for startup and modification	658	7.1	948	7.0	1,584	6.6
Interest during construction	840	9.1	1,190	8.8	1,995	8.2
Subtotal capital investment	8,501	91.9	12,055	89.1	20,204	83.8
Land	284	3.1	693	5.1	2,083	8.6
Working capital	464	5.0	783	5.8	1,817	7.6
Total capital investment	9,249	100.0	13,531	100.0	24,104	100.0

a. Basis
New plant (30-yr life), Midwest plant location, mid-1979 costs.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2 to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Landfill disposal of 60% solids material 1 mi from scrubber facilities, pipelines used for transport of 35% solids thickener underflow to treatment and disposal area.

TABLE 26. CAPITAL INVESTMENTS FOR SYSTEMS OPERATING AT CONSTANT LOAD DURING 30-YR LIFE

Annual operating time, hr	Case[a]	Capital investment, M$			
		Untreated	Dravo	IUCS	Chemfix
5,000	200 MW	10,682	14,739	7,214	9,274
	500 MW	18,937	24,771	10,779	13,515
	1500 MW	40,438	51,998	20,282	24,066
7,000	200 MW	12,882	16,875	7,369	9,432
	500 MW	23,272	30,293	11,159	13,984
	1500 MW	50,462	62,551	21,415	24,453

[a] New plants operating 30 yr; Midwest plant location; mid-1979 costs; coal analysis (wt %): 3.5% S (dry), 16% ash; flyash removed with SO_2 to meet NSPS; limestone scrubbing FGD process with 1.5 stoichiometry based on SO_2 removed.

TABLE 27. SUMMARY OF LAND REQUIREMENTS - ALL PROCESSES

Case	Land required for sludge disposal, acre[a]			
	Untreated	Dravo	IUCS	Chemfix
Base case	407	414	193	198
Variation from base case				
200 MW new	202	193	80	81
200 MW existing, 25-yr remaining life	162	165	59	61
200 MW existing, 20-yr remaining life	112	110	37	38
200 MW existing, 15-yr remaining life	72	74	21	22
Existing, 25-yr remaining life	322	328	143	147
Existing, 20-yr remaining life	222	235	89	91
Existing, 15-yr remaining life	143	145	51	52
1500 MW new	960	975	580	595
1500 MW existing, 25-yr remaining life	761	770	430	442
1500 MW existing, 20-yr remaining life	519	535	267	275
1500 MW existing, 15-yr remaining life	335	343	151	155
12% ash in coal	347	358	159	163
20% ash in coal	461	445	231	237
2% S in coal	301	313	134	138
5% S in coal	497	511	251	258
200 MW, no flyash	124	172	58	43
No flyash	250	345	141	105
1500 MW, no flyash	591	814	404	316
5 mi to disposal	407	414	193	198
10 mi to disposal	407	414	193	198
Fixation additive rate - variation 1	-	406	192	261
Fixation additive rate - variation 2	-	424	194	227
Lime scrubbing process	407	373	168	173
Intermediate ponding and truck to landfill	-	189	-	-
Transport by truck to disposal area	-	-	-	198
Clarify (35% solids) and pump 1 mi	407	-	-	-
Clarify (35% solids) and pump 5 mi	407	-	-	-
Clarify (35% solids) and pump 10 mi	407	-	-	-
Clarify, filter (60% solids) and truck 1 mi	188	-	-	-
Clarify, filter (60% solids) and truck 5 mi	188	-	-	-
Clarify, filter (60% solids) and truck 10 mi	188	-	-	-
200 MW, constrained pond acreage (50% of optimum)	101	97	-	-
200 MW, constrained pond acreage (75% of optimum)	152	145	-	-
Constrained pond acreage (50% of optimum)	204	207	-	-
Constrained pond acreage (75% of optimum)	305	311	-	-
1500 MW, constrained pond acreage (50% of optimum)	480	488	-	-
1500 MW, constrained pond acreage (75% of optimum)	720	731	-	-
Pond settled density (40% solids)	496	-	-	-
Pond settled density (60% solids)	342	-	-	-
Unlined pond	486	-	-	-
Synthetic pond lining ($1.50/yd^2)	-	-	-	-
Synthetic pond lining ($2.50/yd^2)	-	-	-	-
Synthetic pond lining ($3.50/yd^2)	-	-	-	-
Synthetic pond lining ($4.50/yd^2)	-	-	-	-
200 MW, constant-load operating profile (5,000 hr/yr)	229	237	93	96
Constant-load operating profile (5,000 hr/yr)	461	473	228	233
1500 MW, constant-load operating profile (5,000 hr/yr)	1,091	1,118	681	699
200 MW, constant-load operating profile (7,000 hr/yr)	299	304	130	133
Constant-load operating profile (7,000 hr/yr)	601	608	314	327
1500 MW, constant-load operating profile (7,000 hr/yr)	1,419	1,454	953	979

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[a] Ponds are designed for optimum costs unless otherwise specified. Total pond depth is variable. Land requirements for landfill cases are calculated for a 30-ft depth of compacted sludge. The land cost for all cases is $3,500/acre.

Direct costs--There are two categories of direct costs. The first, covering raw materials, is projected 1980 delivered costs to a midwestern power plant location. Estimates of the cost for each raw material are obtained from appropriate suppliers for the Chicago area. The second category of direct cost is conversion costs, which include operating labor and supervision, maintenance labor and materials, electricity, analyses, fuel and maintenance for trucks and landfill equipment, and land preparation costs for landfill disposal operations.

Labor costs are projected for 1980 midwestern rates. Electricity rates depend upon the quantity purchased. Also, the values used are fully allocated costs, as if purchased from an independent source with full capital recovery provided. The quantity of required electricity is estimated on the basis of operating motor horsepower.

Operating labor and supervision for each process is estimated considering the number, size, and complexity of operation of major process equipment. Analyses labor estimates are based on the number of analyses that must be made to maintain process control.

Maintenance costs are derived from percentages of the direct investment for the sludge handling and treatment facilities and the direct investment for pond construction. The percentage values are based on information conerning actual maintenance requirements for similar equipment and processing systems. Fuel and maintenance costs for trucks and landfill equipment are estimated from information obtained from companies operating similar disposal systems or involved in similar transport operations. Land preparation costs for the landfills are based on annual land usage and associated equipment operation costs.

Indirect costs--The two primary indirect cost items are capital charges and overheads. These items are estimated based on current utility practice, interest rates, and authoritative literature sources. Capital charges are applied as average capital charges including depreciation, interim replacements, insurance, taxes, and the cost of capital. The total rate applied depends on the power plant's remaining life and the particular type of disposal system used, since the cost of interim replacements is much higher for systems using trucks and landfill equipment than those using a disposal pond.

Plant overhead is estimated at 50% of conversion costs less utilities. Administrative overhead is 10% of operating labor costs.

Lifetime Revenue Requirements--

Annual revenue requirements are estimated on the assumption that annual operating time for the disposal system is 7000 hr. These estimates are suitable for comparing processes and measuring the effect of process variable changes. Also, they may represent operating profiles similar to those during the early years of a plant's life. However, most power units have a declining load over their life and seldom operate in later years at the 7000-hr level assumed for the annual revenue requirement calculations. Since revenue requirement estimates are needed which reflect the operating profiles of older plants, lifetime revenue requirement estimates are included in this evaluation. These estimates consider the variations in capital charges and operating profile with plant age.

Capital charges--The portion of indirect costs that reflects the cost of capital and taxes is based on undepreciated capital investment. A computer program was used to calculate the revenue requirements for each year over the plant life. Straight-line depreciation is used and capital charges decrease uniformly with depreciation over the life of the disposal system.

Operating profile--The actual quantities affecting direct costs (raw materials, electricity, operating labor and supervision, maintenance, and analyses) were estimated in order to calculate annual revenue requirements for each disposal system based on 7000 hr annual operating time. As the plant's remaining life decreases, the operating profile of the plant and the quantities of raw materials, analyses, and electricity also decrease. The projected costs for these items were modified to show the effect of decreased operating load on total revenue requirements. The annual quantities of each item are scaled proportional to the annual operating hr for the plant. Annual quantities for operating labor and supervision are scaled proportional to the annual operating hr raised to the 0.5 power. The overhead charges (10% of operating labor and supervision) included in the indirect costs are also scaled proportional to annual operating hr raised to the 0.5 power.

The direct charges for maintenance are scaled proportional to the annual operating hr raised to the 0.6 power. These adjustments to total annual revenue requirements to yield lifetime revenue requirements provide information for more accurately estimating revenue requirements for later years in the disposal system's life.

Constant-Load Revenue Requirements--

The capacity of a power plant is often held constant or increased with time by adding new generating units as the capacity of older units is reduced by age. When this occurs, the capacity of the sludge disposal system must be held constant or increased to meet the power plant's demands.

In this study two types of constant-load revenue requirements, annual and lifetime, are considered. The annual values are based on average capital charges over a 30-yr plant life and a revised capital investment using an adjusted disposal pond or landfill area as compared to a declining profile-type operation. The lifetime values are based on declining capital charges and the same revised capital investment. Estimates are included to show the annual and lifetime revenue requirements for plants with constant annual operating loads of 5000 and 7000 hr over a 30-yr life. Estimates are made for 200-, 500-, and 1500-MW plants with the untreated ponding, Dravo, IUCS, and Chemfix systems for sludge disposal.

Results

Annual Revenue Requirements--

The total annual revenue requirements for the disposal systems evaluated for the base case 500-MW power plant are as follows:

Untreated ponding	$3,280,000
IUCS process	$5,291,000
Dravo process	$6,701,000
Chemfix process	$6,988,000

The revenue requirement summary tables for the 121 case variations of the four primary disposal methods are given in Appendix A. Each summary table includes the cost of direct and indirect revenue requirement items. Tables 28-31 summarize the total annual revenue requirements for the case variations of the four disposal alternatives. The unit revenue requirements (mills/kWh, $/ton dry solids, $/ton wet solids) for the 121 case variations are summarized in Table 32.

Lifetime Revenue Requirements--

Twelve summary tables (computer projections) are included in Appendix B to show detailed year-to-year revenue requirement estimates for 200-, 500-, and 1500-MW plants using the four sludge disposal processes. For these plants the revenue requirements are estimated for each year of the 30-yr operating life.

Table 33 shows summarized results of the lifetime revenue requirement estimates for the four disposal systems. The cumulative (30 yr) net revenue requirements are shown for the 12 case variations. These projections are prepared on a regulated economic basis, as mentioned earlier on revenue requirements, and correspond to the 30-yr operating profile of the plant established in the power plant design premises. The overall net increase or decrease in power cost is shown for each year on tables in Appendix B.

Constant-Load Revenue Requirements--

Constant-load annual revenue requirements are shown in Table 34 for systems operating at 5000 and 7000 hr/yr for plants having 30-yr lives.

Appendix C includes a summary of the constant-load lifetime revenue requirements, showing the detailed year-to-year variations and the net change for each of the 24 case variations of systems operating for 30 yr. Tables 35 and 36 summarize the cumulative (30 yr) net revenue requirements for these case variations (four disposal systems for 200-, 500-, and 1500-MW plants). Constant operating loads of 5000 and 7000 operating hr/yr are considered.

TABLE 28. SUMMARY OF TOTAL ANNUAL REVENUE REQUIREMENTS - UNTREATED PROCESS[a]

Case	Total annual amount, k$	Unit revenue requirements		
		Mills/kWh	$/ton dry sludge	$/ton wet sludge
Base case[b]	3,280	0.94	8.08	4.04
Variation from base case				
200 MW new	2,014	1.44	12.12	6.06
200 MW existing, 25-yr remaining life	1,814	1.32	10.62	5.31
200 MW existing, 20-yr remaining life	1,605	1.15	9.26	4.63
200 MW existing, 15-yr remaining life	1,433	1.02	8.27	4.14
Existing, 25-yr remaining life	2,906	0.83	7.01	3.51
Existing, 20-yr remaining life	2,435	0.70	5.87	2.94
Existing, 15-yr remaining life	2,130	0.61	5.13	2.57
1500 MW new	6,746	0.64	5.55	2.77
1500 MW existing, 25-yr remaining life	5,827	0.55	4.69	2.35
1500 MW existing, 20-yr remaining life	4,726	0.45	3.80	1.90
1500 MW existing, 15-yr remaining life	3,969	0.38	3.19	1.60
12% ash in coal	2,902	0.83	8.68	4.34
20% ash in coal	3,609	1.03	7.44	3.72
2% S in coal	2,639	0.75	9.37	4.69
5% S in coal	3,869	1.10	7.35	3.68
200 MW, no flyash	1,495	1.07	17.08	8.50
No flyash	2,289	0.65	10.63	5.32
1500 MW, no flyash	4,546	0.43	7.04	3.52
5 mi to disposal	5,527	1.58	13.61	6.81
10 mi to disposal	7,504	2.14	18.48	9.24
Fixation additive rate - variation 1	-	-	-	-
Fixation additive rate - variation 2	-	-	-	-
Lime scrubbing process	3,136	0.9	8.87	4.44
Intermediate ponding and truck to landfill	-	-	-	-
Transport by truck to disposal area	-	-	-	-
Clarify (35% solids) and pump 1 mi	3,694	1.06	9.10	4.55
Clarify (35% solids) and pump 5 mi	5,195	1.48	12.79	6.40
Clarify (35% solids) and pump 10 mi	6,450	1.84	15.89	7.95
Clarify, filter (60% solids) and truck 1 mi	3,809	1.09	9.38	4.69
Clarify, filter (60% solids) and truck 5 mi	4,925	1.41	12.13	6.07
Clarify, filter (60% solids) and truck 10 mi	5,818	1.66	14.40	7.20
200 MW, constrained pond acreage (50% of optimum)	2,462	1.76	14.81	7.41
200 MW, constrained pond acreage (75% of optimum)	2,033	1.45	12.23	6.12
Constrained pond acreage (50% of optimum)	4,119	1.18	10.15	5.08
Constrained pond acreage (75% of optimum)	3,365	0.96	8.29	4.15
1500 MW, constrained pond acreage (50% of optimum)	8,985	0.86	7.40	3.70
1500 MW, constrained pond acreage (75% of optimum)	7,037	0.67	5.79	2.90
Pond settled density (40% solids)	3,747	1.07	11.54	5.77
Pond settled density (60% solids)	2,949	0.84	6.05	3.03
Unlined pond	2,765	0.79	6.91	3.41
Synthetic pond lining ($1.50/yd^2)	3,882	1.11	9.50	4.75
Synthetic pond lining ($2.50/yd^2)	4,253	1.21	10.47	5.24
Synthetic pond lining ($3.50/yd^2)	4,590	1.31	11.30	5.65
Synthetic pond lining ($4.50/yd^2)	4,900	1.40	12.07	6.04

a. Basis
Midwest plant location, mid-1980 costs; 7,000 hr/yr plant on-stream time; SO_2 and flyash removed to meet NSPS.

b. Base case
New 500-MW plant with 30-yr life; direct ponding of 15% solids slurry in a clay-lined pond 1 mi from scrubber facilities; settled density in pond - 50% solids.

TABLE 29. SUMMARY OF TOTAL ANNUAL REVENUE REQUIREMENTS - DRAVO PROCESS[a]

Case	Total annual amount, k$	Unit revenue requirements Mills/kWh	 $/ton dry sludge	 $/ton wet sludge
Base case[b]	6,701	1.91	15.32	7.66
Variation from base case				
200 MW new	3,643	2.60	20.41	10.21
200 MW existing, 25-yr remaining life	3,672	2.62	19.87	9.94
200 MW existing, 20-yr remaining life	3,461	2.47	18.73	9.37
200 MW existing, 15-yr remaining life	3,390	2.42	18.35	9.18
Existing, 25-yr remaining life	6,377	1.82	14.23	7.12
Existing, 20-yr remaining life	5,941	1.70	13.26	6.63
Existing, 15-yr remaining life	5,728	1.64	12.78	6.39
1500 MW new	14,264	1.36	10.87	5.44
1500 MW existing, 25-yr remaining life	13,821	1.32	10.30	5.15
1500 MW existing, 20-yr remaining life	12,749	1.21	9.50	4.75
1500 MW existing, 15-yr remaining life	12,138	1.16	9.04	4.52
12% ash in coal	5,924	1.69	16.43	8.22
20% ash in coal	7,406	2.12	15.58	7.79
2% S in coal	5,314	1.52	17.45	8.73
5% S in coal	8,007	2.29	14.08	7.04
200 MW, no flyash	3,063	2.19	25.74	12.84
No flyash	5,073	1.45	17.48	8.74
1500 MW, no flyash	10,448	1.00	12.01	6.01
5 mi to disposal	8,124	2.32	18.57	9.29
10 mi to disposal	9,360	2.67	21.39	10.70
Fixation additive rate - variation 1	6,052	1.73	14.09	7.05
Fixation additive rate - variation 2	7,577	2.16	16.85	8.43
Lime scrubbing process	6,168	1.76	8.10	4.05
Intermediate ponding and truck to landfill	6,620	1.89	15.13	7.57
200 MW, constrained pond acreage (50% of optimum)	4,423	3.16	24.78	12.39
200 MW, constrained pond acreage (75% of optimum)	4,134	2.95	23.16	11.58
Constrained pond acreage (50% of optimum)	9,109	2.60	20.82	10.41
Constrained pond acreage (75% of optimum)	7,901	2.25	18.06	9.03
1500 MW, constrained pond acreage (50% of optimum)	20,366	1.94	15.52	7.76
1500 MW, constrained pond acreage (75% of optimum)	17,290	1.65	13.17	6.59

a. Basis
Midwest plant location, mid-1980 costs; 7,000 hr/yr plant on-stream time; SO_2 and flyash removed to meet NSPS.

b. Base case
New 500-MW plant with 30-yr life; ponding of 35% solids slurry in a clay-lined pond 1 mi from scrubber facilities; settled density in pond - 50% solids; pipeline transport to the disposal area; Calcilox for stabilization (7% of dry sludge).

TABLE 30. SUMMARY OF TOTAL ANNUAL REVENUE REQUIREMENTS - IUCS PROCESS[a]

Case	Total annual amount, k$	Unit revenue requirements		
		Mills/kWh	$/ton dry sludge	$/ton wet sludge
Base case[b]	5,291	1.51	12.55	7.63
Variation from base case				
200 MW new	3,567	2.55	20.68	12.59
200 MW existing, 25-yr remaining life	3,699	2.64	20.66	12.73
200 MW existing, 20-yr remaining life	3,725	2.66	20.80	12.82
200 MW existing, 15-yr remaining life	3,822	2.73	21.35	13.16
Existing, 25-yr remaining life	5,402	1.54	12.55	7.63
Existing, 20-yr remaining life	5,430	1.55	12.62	7.68
Existing, 15-yr remaining life	5,559	1.59	12.92	7.86
1500 MW new	10,411	0.99	8.23	5.02
1500 MW existing, 25-yr remaining life	10,656	1.01	8.24	5.02
1500 MW existing, 20-yr remaining life	10,684	1.02	8.26	5.04
1500 MW existing, 15-yr remaining life	10,900	1.04	8.43	5.14
12% ash in coal	4,533	1.30	13.05	7.94
20% ash in coal	5,971	1.71	11.84	7.23
2% S in coal	4,654	1.33	15.57	9.71
5% S in coal	6,188	1.77	11.29	6.88
200 MW, no flyash	3,396	2.43	37.03	16.45
No flyash	4,650	1.33	20.87	9.23
1500 MW, no flyash	8,162	0.78	12.17	5.42
5 mi to disposal	6,490	1.85	15.40	9.37
10 mi to disposal	7,475	2.14	17.73	10.78
Fixation additive rate - variation 1	4,994	1.43	11.96	7.28
Fixation additive rate - variation 2	5,511	1.57	12.95	7.91
Lime scrubbing process	5,093	1.46	13.88	8.46

a. Basis
Midwest plant location, mid-1980 costs; 7,000 hr/yr plant on-stream time; SO_2 and flyash removed to meet NSPS.

b. Base case
New 500-MW plant with 30-yr life; landfill disposal of 60% solids material 1 mi from scrubber facilities; truck transport of treated sludge to disposal area; lime for stabilization (4% of dry sludge).

TABLE 31. SUMMARY OF TOTAL ANNUAL REVENUE REQUIREMENTS - CHEMFIX PROCESS[a]

Case	Total annual amount, k$	Unit revenue requirements Mills/kWh	$/ton dry sludge	$/ton wet sludge
Base case[b]	6,988	2.00	16.51	10.08
Variation from base case				
200 MW new	4,529	3.24	26.14	15.59
200 MW existing, 25-yr remaining life	4,695	3.35	26.11	15.60
200 MW existing, 20-yr remaining life	4,730	3.38	26.31	15.72
200 MW existing, 15-yr remaining life	4,856	3.47	27.01	16.13
Existing, 25-yr remaining life	7,152	2.04	16.55	9.87
Existing, 20-yr remaining life	7,191	2.05	16.64	9.92
Existing, 15-yr remaining life	7,329	2.10	17.03	10.16
1500 MW new	14,362	1.37	11.31	6.74
1500 MW existing, 25-yr remaining life	14,749	1.40	11.36	6.76
1500 MW existing, 20-yr remaining life	14,791	1.41	11.39	6.78
1500 MW existing, 15-yr remaining life	15,053	1.43	11.59	6.90
12% ash in coal	6,229	1.78	17.86	10.66
20% ash in coal	7,600	2.17	15.00	8.93
2% S in coal	5,935	1.70	20.19	12.02
5% S in coal	8,263	2.36	15.01	8.94
200 MW, no flyash	3,766	2.69	40.89	24.45
No flyash	5,184	1.48	23.17	13.84
1500 MW, no flyash	9,771	0.93	14.30	8.52
5 mi to disposal	8,675	2.48	20.49	12.52
10 mi to disposal	10,003	2.86	23.63	14.43
Fixation additive rate - variation 1	13,651	3.90	28.71	14.61
Fixation additive rate - variation 2	10,099	2.89	20.99	12.42
Lime scrubbing process	6,200	1.77	16.83	10.01
Intermediate ponding and truck to landfill	-	-	-	-
Transport by truck to disposal area	6,698	1.91	15.82	9.66

a. Basis
Midwest plant location, mid-1980 costs; SO_2 and flyash removed to meet NSPS.

b. Base case
New 500-MW plant with 30-yr life; landfill disposal of 60% solids material 1 mi from scrubber facilities; pipeline transport to treatment and disposal area; fixation additives: Portland cement (7% of dry sludge) and sodium silicate (2% of dry sludge).

TABLE 32. SUMMARY - UNIT REVENUE REQUIREMENTS - ALL PROCESSES

Case	Untreated disposal[a]			Dravo[b]			IUCS[c]			Chemfix[d]		
	Mills/kWh	$/ton dry sludge[e]	$/ton wet sludge[f]	Mills/kWh	$/ton dry sludge	$/ton wet sludge	Mills/kWh	$/ton dry sludge	$/ton wet sludge	Mills/kWh	$/ton dry sludge	$/ton wet sludge
Base case[g]	0.94	8.08	4.04	1.91	15.32	7.66	1.51	12.55	7.63	2.00	16.51	10.08
Variation from base case												
200 MW new	1.44	12.12	6.06	2.60	20.41	10.21	2.55	20.68	12.59	3.24	26.14	15.59
200 MW existing, 25-yr remaining life	1.32	10.62	5.31	2.62	19.87	9.94	2.64	20.66	12.73	3.35	26.11	15.60
200 MW existing, 20-yr remaining life	1.15	9.26	4.63	2.47	18.73	9.37	2.66	20.80	12.82	3.38	26.31	15.72
200 MW existing, 15-yr remaining life	1.02	8.27	4.14	2.42	18.35	9.18	2.73	21.35	13.16	3.47	27.01	16.13
Existing, 25-yr remaining life	0.83	7.01	3.51	1.82	14.23	7.12	1.54	12.55	7.63	2.04	16.55	9.87
Existing, 20-yr remaining life	0.70	5.87	2.94	1.70	13.26	6.63	1.55	12.62	7.68	2.05	16.64	9.92
Existing, 15-yr remaining life	0.61	5.13	2.57	1.64	12.78	6.39	1.59	12.92	7.86	2.10	17.03	10.16
1500 MW new	0.64	5.55	2.77	1.36	10.87	5.44	0.99	8.23	5.02	1.37	11.31	6.74
1500 MW existing, 25-yr remaining life	0.55	4.69	2.35	1.32	10.30	5.15	1.01	8.24	5.02	1.40	11.36	6.76
1500 MW existing, 20-yr remaining life	0.45	3.80	1.90	1.21	9.50	4.75	1.02	8.26	5.04	1.41	11.39	6.78
1500 MW existing, 15-yr remaining life	0.38	3.19	1.60	1.16	9.06	4.53	1.04	8.43	5.14	1.43	11.59	6.90
12% ash in coal	0.83	8.68	4.34	1.69	16.43	8.22	1.30	13.05	7.94	1.78	17.86	10.66
20% ash in coal	1.03	7.44	3.72	2.12	15.58	7.79	1.71	11.84	7.23	2.17	15.00	8.93
2% S in coal	0.75	9.37	4.69	1.52	17.45	8.73	1.33	15.57	9.71	1.70	20.19	12.02
5% S in coal	1.10	7.35	3.68	2.29	14.08	7.04	1.77	11.29	6.88	2.36	15.01	8.94
200 MW, no flyash	1.07	17.08	8.50	2.19	25.74	12.87	2.43	37.03	16.45	2.69	40.89	24.45
No flyash	0.65	10.63	5.32	1.45	17.48	8.74	1.33	20.87	9.23	1.48	23.17	13.84
1500 MW, no flyash	0.43	7.04	3.52	1.00	12.01	6.01	0.78	12.17	5.42	0.93	11.30	8.52
5 mi to disposal	1.58	13.61	6.81	2.32	18.57	9.29	1.85	15.40	9.37	2.48	20.69	12.52
10 mi to disposal	2.14	18.48	9.24	2.67	21.39	10.70	2.14	17.73	10.78	2.86	23.63	14.43
Fixation additive rate - variation 1	-	-	-	1.73	14.09	7.05	1.43	11.96	7.28	3.90	28.71	14.61
Fixation additive rate - variation 2	-	-	-	2.16	16.85	8.43	1.57	12.95	7.91	2.89	20.99	12.42
Lime scrubbing process	0.90	8.87	4.44	1.76	8.10	4.05	1.46	13.88	8.46	1.77	16.83	10.01
Intermediate ponding and truck to landfill	-	-	-	1.89	15.13	7.57	-	-	-	-	-	-
Transport by truck to disposal area	-	-	-	-	-	-	-	-	-	1.91	15.82	9.66
Clarify (35% solids) and pump 1 mi	1.06	9.10	4.55	-	-	-	-	-	-	-	-	-
Clarify (35% solids) and pump 5 mi	1.48	12.79	6.40	-	-	-	-	-	-	-	-	-
Clarify (35% solids) and pump 10 mi	1.84	15.89	7.95	-	-	-	-	-	-	-	-	-
Clarify, filter (60% solids) and truck 1 mi	1.09	9.38	4.69	-	-	-	-	-	-	-	-	-
Clarify, filter (60% solids) and truck 5 mi	1.41	12.13	6.07	-	-	-	-	-	-	-	-	-
Clarify, filter (60% solids) and truck 10 mi	1.66	14.40	7.20	-	-	-	-	-	-	-	-	-
200 MW, constrained pond acreage (50% of optimum)	1.76	14.81	7.41	3.16	24.78	12.39	-	-	-	-	-	-
200 MW, constrained pond acreage (75% of optimum)	1.45	12.23	6.12	2.95	23.16	11.58	-	-	-	-	-	-
Constrained pond acreage (50% of optimum)	1.18	10.15	5.08	2.60	20.82	10.41	-	-	-	-	-	-
Constrained pond acreage (75% of optimum)	0.96	8.29	4.15	2.25	18.06	9.03	-	-	-	-	-	-
1500 MW, constrained pond acreage (50% of optimum)	0.86	7.40	3.70	1.94	15.52	7.76	-	-	-	-	-	-
1500 MW, constrained pond acreage (75% of optimum)	0.67	5.79	2.90	1.65	13.17	6.59	-	-	-	-	-	-
Pond settled density (40% solids)	1.07	11.54	5.77	-	-	-	-	-	-	-	-	-
Pond settled density (60% solids)	0.84	6.05	3.03	-	-	-	-	-	-	-	-	-
Unlined pond	0.79	6.81	3.41	-	-	-	-	-	-	-	-	-
Synthetic pond lining ($1.50/yd^2)	1.11	9.50	4.75	-	-	-	-	-	-	-	-	-
Synthetic pond lining ($2.50/yd^2)	1.21	10.47	5.24	-	-	-	-	-	-	-	-	-
Synthetic pond lining ($3.50/yd^2)	1.31	11.30	5.65	-	-	-	-	-	-	-	-	-
Synthetic pond lining ($4.50/yd^2)	1.40	12.07	6.04	-	-	-	-	-	-	-	-	-

a. Direct ponding of 15% solids slurry; clay-lined pond; pump 1 mi from scrubber facilities; 50% solids settled sludge in pond.
b. Ponding of 35% solids slurry; clay-lined pond; pump 1 mi from scrubber facilities; 50% solids settled sludge in pond; treated with Calcilox (7% of dry sludge) and Thiosorbic lime (1% of dry sludge).
c. Landfill disposal of 60% solids material; 1 mi to landfill from scrubber facilities; trucks used for transport of treated sludge; treated with lime (4% of dry solids).
d. Landfill disposal of 60% solids material; 1 mi to landfill from scrubber facilities; pipeline used for transport of thickener underflow to disposal and treatment area; treated with Portland cement (7% of dry solids) and sodium silicate (2% of dry solids).
e. The amount of dry solids in the scrubber effluent for disposal.
f. The amount of wet material that is actually ponded or landfilled, i.e., 50% solids sludge for untreated base case and material placed in landfill in IUCS cases.
g. New 500-MW plant (30-yr life); 7,000 hr/yr on-stream time; Midwest plant location; mid-1980 costs; limestone process with 1.5 stoichiometry based on SO_2 removed; coal analysis (by wt): 3.5% S (dry basis), 16% ash; SO_2 and flyash removed to meet NSPS.

TABLE 33. SUMMARY - LIFETIME REVENUE REQUIREMENTS FOR ALL PROCESSES (ACTUAL AND DISCOUNTED CUMULATIVE TOTAL AND UNIT VALUES[a])

Case[b]	Cumulative actual net increase in revenue requirements, $	Lifetime average increase in unit revenue requirements			Cumulative present worth net increase in revenue requirements, $[c]	Levelized increase in unit revenue requirements[d]		
		Mills/kWh	$/ton dry solids	$/ton wet solids		Mills/kWh	$/ton dry solids	$/ton wet solids
Untreated								
200 MW	58,750,000	2.30	19.40	9.70	20,204,800	2.03	6.67	3.34
500 MW	97,757,800	1.53	13.22	6.61	33,612,100	1.35	4.55	2.27
1500 MW	203,309,200	1.06	9.18	4.59	69,819,400	0.94	3.15	1.58
Dravo								
200 MW	94,392,200	3.70	29.03	14.52	33,368,200	3.36	10.26	5.13
500 MW	175,764,900	2.76	22.06	11.03	62,052,600	2.50	7.79	3.89
1500 MW	375,002,700	1.96	15.69	7.84	133,456,200	1.79	5.58	2.79
IUCS								
200 MW	89,013,000	3.49	28.33	17.24	30,584,100	3.08	9.73	5.92
500 MW	131,224,200	2.06	17.09	10.40	45,381,700	1.83	5.89	3.58
1500 MW	254,498,000	1.33	11.05	6.73	88,798,600	1.19	4.33	2.64
Chemfix								
200 MW	111,241,300	3.36	35.25	21.02	38,655,100	3.89	12.25	7.31
500 MW	167,942,300	2.63	21.78	13.30	59,099,300	2.38	7.67	4.68
1500 MW	333,190,900	1.74	14.41	8.58	119,154,500	1.60	5.15	3.07

a. Basis
Over previously defined power plant operating profile; 30-yr life; 7,000 hr - 10 yr, 5,000 hr - 5 yr, 3,500 hr - 5 yr, 1,500 hr - 10 yr; Midwest plant location, 1980 revenue requirements; constant labor cost assumed over life of project.

b. New plants, coal analysis (wt %): 3.5% S (dry), 16% ash; flyash removed with SO_2 to meet NSPS.

c. Discounted at 10% to initial year.

d. Equivalent to discounted process cost over life of power plant.

TABLE 34. ANNUAL REVENUE REQUIREMENTS FOR SYSTEMS OPERATING AT CONSTANT LOAD DURING 30-YR LIFE

Annual operating time, hr	Case[a]	Annual revenue requirements, $			
		Untreated	Dravo	IUCS	Chemfix
5,000	200 MW	2,156,300	3,562,100	3,423,600	4,391,400
5,000	500 MW	3,552,600	6,421,300	4,958,200	6,247,000
5,000	1500 MW	7,361,700	13,692,300	9,427,200	12,166,100
7,000	200 MW	2,519,700	4,124,700	3,586,900	4,548,700
7,000	500 MW	4,276,500	7,718,200	5,340,200	7,037,800
7,000	1500 MW	9,052,500	17,049,900	10,555,200	14,511,100

a. New plants operating 30 yr, Midwest plant location, mid-1979 costs; coal analysis (wt %): 3.5% S (dry), 16% ash; flyash removed with SO_2 to meet NSPS; limestone scrubbing FGD process.

TABLE 35. SUMMARY - LIFETIME REVENUE REQUIREMENTS FOR SYSTEMS OPERATING AT CONSTANT LOAD OF 5,000 HR/YR DURING 30-YR LIFE (ACTUAL AND DISCOUNTED CUMULATIVE TOTAL AND UNIT VALUES[a])

Case[b]	Cumulative actual net increase in revenue requirements, $	Lifetime average increase in unit revenue requirements			Cumulative present worth net increase in revenue requirements, $[c]	Levelized increase in unit revenue requirements[d]		
		Mills/kWh	$/ton dry solids	$/ton wet solids		Mills/kWh	$/ton dry solids	$/ton wet solids
Untreated								
200 MW	68,635,900	2.29	19.57	9.63	22,269,300	2.68	6.25	3.13
500 MW	113,972,700	1.52	13.10	6.55	37,296,900	1.80	4.29	2.14
1500 MW	238,074,400	1.06	9.13	4.57	78,056,500	1.25	2.99	1.50
Dravo								
200 MW	111,652,500	3.72	29.19	14.60	35,498,100	4.28	9.28	4.64
500 MW	202,043,900	2.69	21.55	10.78	63,826,800	3.08	6.81	3.40
1500 MW	432,232,700	1.92	15.37	7.68	135,328,300	2.17	4.81	2.41
IUCS								
200 MW	105,897,500	3.53	28.64	17.42	31,497,700	3.79	8.52	5.18
500 MW	154,682,700	2.06	17.13	10.42	45,980,100	2.22	5.09	3.10
1500 MW	297,631,200	1.32	10.98	6.68	88,019,300	1.41	3.25	1.98
Chemfix								
200 MW	135,579,800	4.52	36.52	21.78	40,359,100	4.86	10.87	6.48
500 MW	194,309,700	2.59	21.42	13.08	57,798,000	2.79	6.37	3.89
1500 MW	382,117,300	1.70	14.04	8.37	112,489,900	1.81	4.13	2.46

a. Basis
Midwest plant location, 1980 revenue requirements; 30-yr life; 5,000 hr/yr; 150,000 hr total operating time.

b. New plants, coal analysis (wt %); 3.5% S (dry), 16% ash; flyash removed with SO_2 to meet NSPS.

c. Discounted at 10% to initial year.

d. Equivalent to discounted process cost over life of power plant.

TABLE 36. SUMMARY - LIFETIME REVENUE REQUIREMENTS FOR SYSTEMS OPERATING AT CONSTANT LOAD OF 7,000 HR/YR DURING 30-YR LIFE (ACTUAL AND DISCOUNTED CUMULATIVE TOTAL AND UNIT VALUES[a])

Case[b]	Cumulative actual net increase in revenue requirements, $	Lifetime average increase in unit revenue requirements			Cumulative present worth net increase in revenue requirement, $[c]	Levelized increase in unit revenue requirements[d]		
		Mills/kWh	$/ton dry solids	$/ton wet solids		Mills/kWh	$/ton dry solids	$/ton wet solids
Untreated								
200 MW	80,584,600	1.92	16.16	8.08	26,228,200	2.26	5.26	2.63
500 MW	137,899,200	1.31	11.32	5.66	45,197,300	1.56	3.71	1.86
1500 MW	293,677,800	0.93	8.05	4.02	96,399,600	1.11	2.64	1.32
Dravo								
200 MW	129,537,700	3.08	24.19	12.10	41,066,500	3.53	7.67	3.83
500 MW	243,352,900	2.32	18.54	9.27	76,570,300	2.64	5.83	2.92
1500 MW	538,992,900	1.71	13.69	6.84	167,889,600	1.93	4.26	2.13
IUCS								
200 MW	111,398,500	2.65	21.52	13.10	33,019,700	2.84	6.38	3.88
500 MW	167,635,400	1.60	13.26	8.06	49,563,800	1.80	3.92	2.38
1500 MW	335,937,400	1.07	8.85	5.38	98,617,900	1.25	2.60	1.58
Chemfix								
200 MW	140,934,100	3.36	27.12	16.17	41,840,600	3.60	8.04	4.80
500 MW	219,892,700	2.09	17.32	10.58	64,876,200	2.23	5.11	3.12
1500 MW	457,926,200		12.02	7.16	133,464,500		3.50	2.09

a. Basis
Midwest plant location, 1980 revenue requirements; 30-yr life; 7,000 hr/yr; 210,000 hr total operating time.

b. New plants, coal analysis (wt %); 3.5% S (dry), 16% ash; flyash removed with SO_2 to meet NSPS.

c. Discounted at 10% to initial year.

d. Equivalent to discounted process cost over life of power plant.

SENSITIVITY ANALYSES

The sensitivities of variations of several process and plant parameters were studied. The effects of these variables on total capital investment and revenue requirements are discussed in the following paragraphs.

Power Plant Size

Figures 14 and 15 show the relationships between power plant size and total capital investment and total annual revenue requirements for new plants. Figures 16-21 show the effect of plant age and power plant size on total capital investment and total annual revenue requirements. The untreated pond disposal alternative becomes the most favorable alternative (capital investment) as the remaining life of the plant is decreased. Total annual revenue requirements are the least for the untreated disposal alternative in every case (new, existing, etc.). Dravo ponding becomes more desirable (not most desirable) with respect to other processes as the remaining life of the plant is decreased. Figure 22 shows the effects of plant size on unit capital investment and for a new plant. For the same cases the annual unit revenue requirements for new plants are shown in Figures 23-26. The effect of plant size on levelized unit revenue requirements (mills/kWh) is shown in Figure 27.

The total capital and annual revenue requirements are increased for plants operating at constant annual loads over their 30-yr life. Figures 28-31 show the effects of these variations on total capital investment and annual revenue requirements for 200-, 500-, and 1500-MW new plants.

Sludge Rate

Several of the case variations considered in this study involved primarily a change in the sludge rate from the FGD system. The unit revenue requirement ($/ton of dry solids for disposal) was calculated for a range of sludge production rates. Figures 32 and 33 show these values. The economics of scale is known to be significant up to about 200 tons dry solids/hr.

S Content in Coal

The effect of S content in coal on total capital investment is shown in Figure 34. Figure 35 shows relationship between S in coal and annual revenue requirements.

Ash in Coal

Figures 36 and 37 show the relationship between the percent ash in coal and total capital investment and annual revenue requirement.

Independent Flyash Removal

Disposal systems were estimated for new 200-, 500-, and 1500-MW plants that removed only SO_2 in the FGD system (flyash was removed with an ESP and handled separately from SO_2 sludge for disposal). The total capital investment and annual revenue requirements for these systems are shown in Figures 38 and 39 as functions of power plant size. Ash handling and disposal costs are not included for these cases.

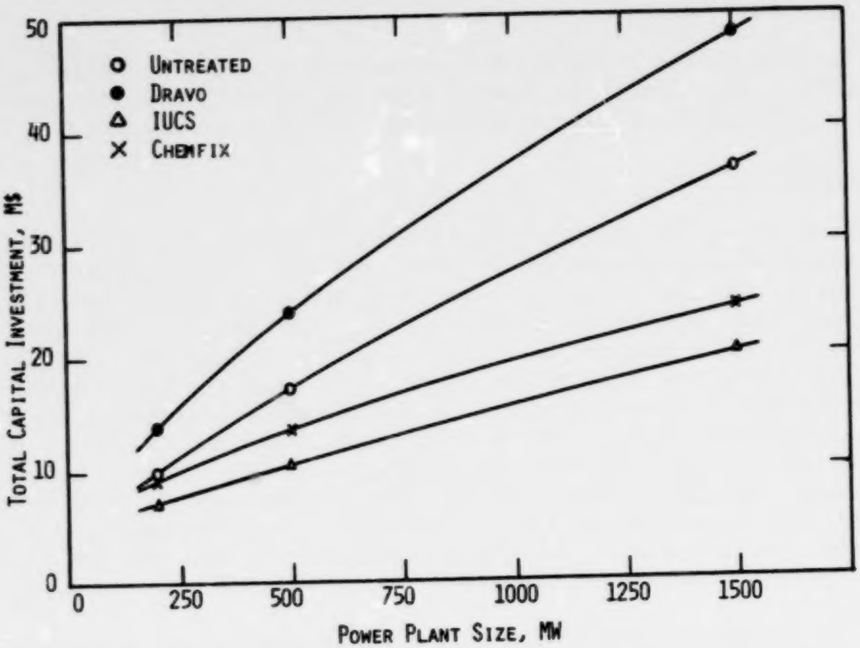

Figure 14. All processes. Effect of power plant size on total capital investment. New plants.

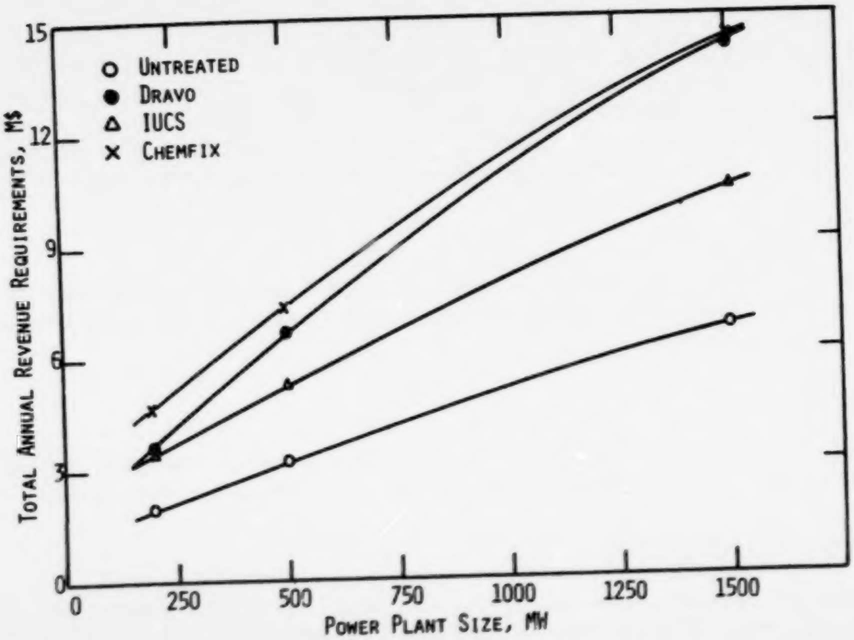

Figure 15. All processes. Effect of power plant size on total annual revenue requirements. New plants.

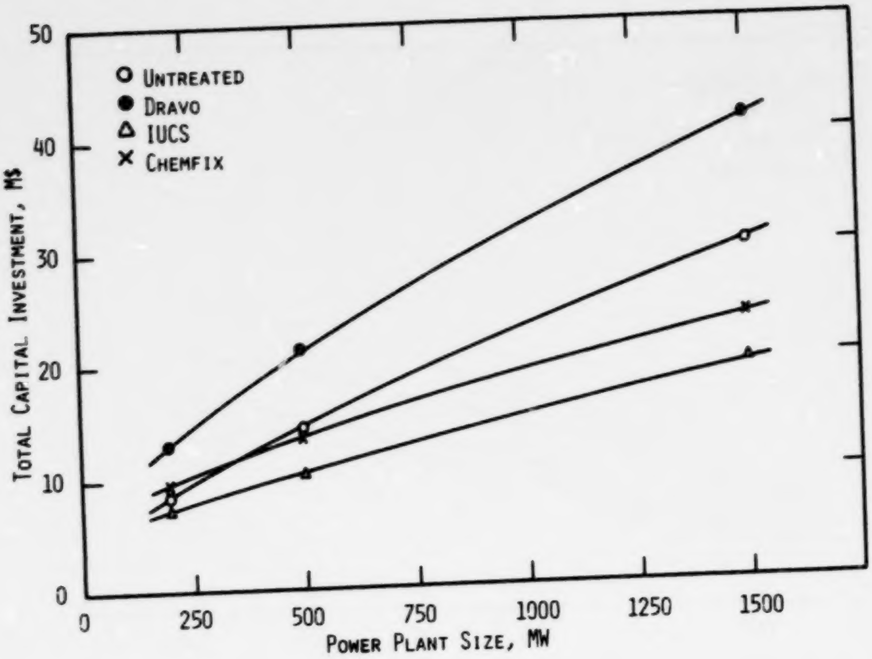

Figure 16. All processes. Effect of power plant size on total capital investment. Existing plant with with 25-yr remaining life.

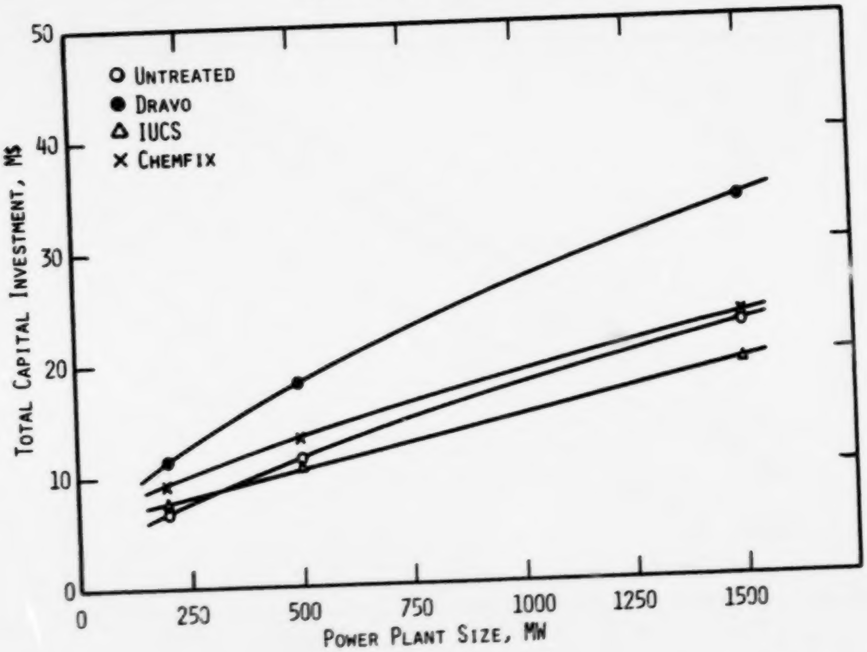

Figure 17. All processes. Effect of power plant size on total capital investment. Existing plant with 20-yr remaining life.

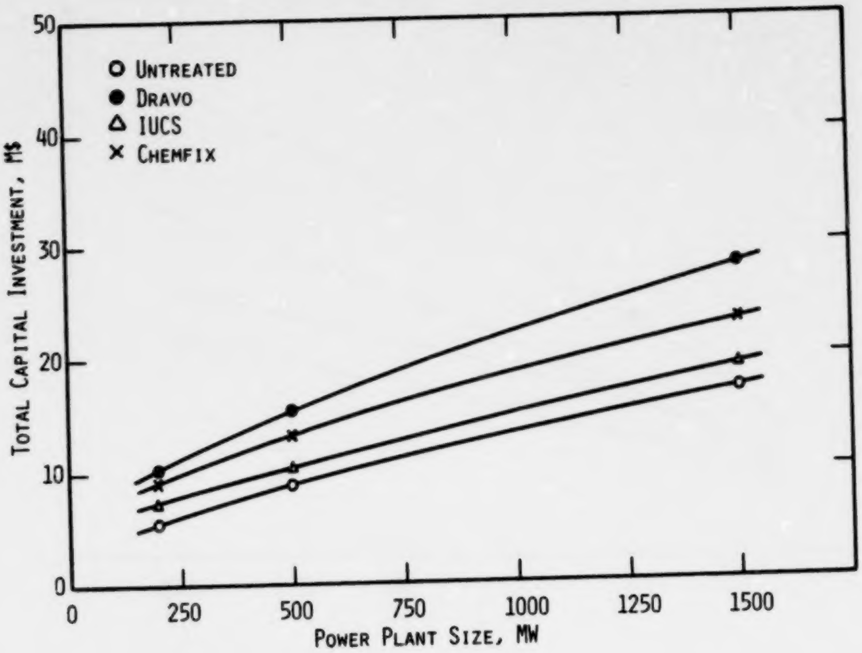

Figure 18. All processes. Effect of power plant size on total capital investment. Existing plant with 15-yr remaining life.

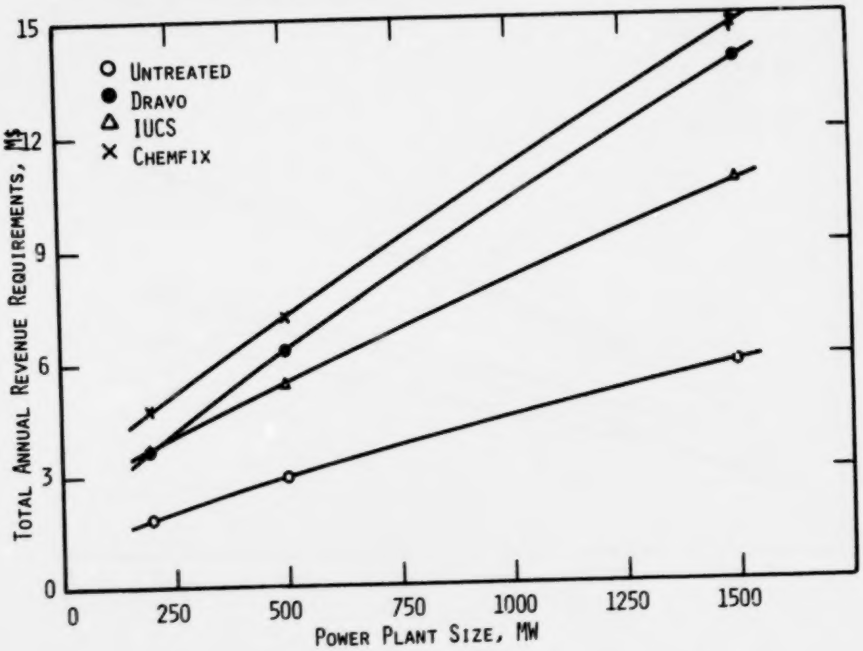

Figure 19. All processes. Effect of power plant size on total annual revenue requirements. Existing plant with 25-yr remaining life.

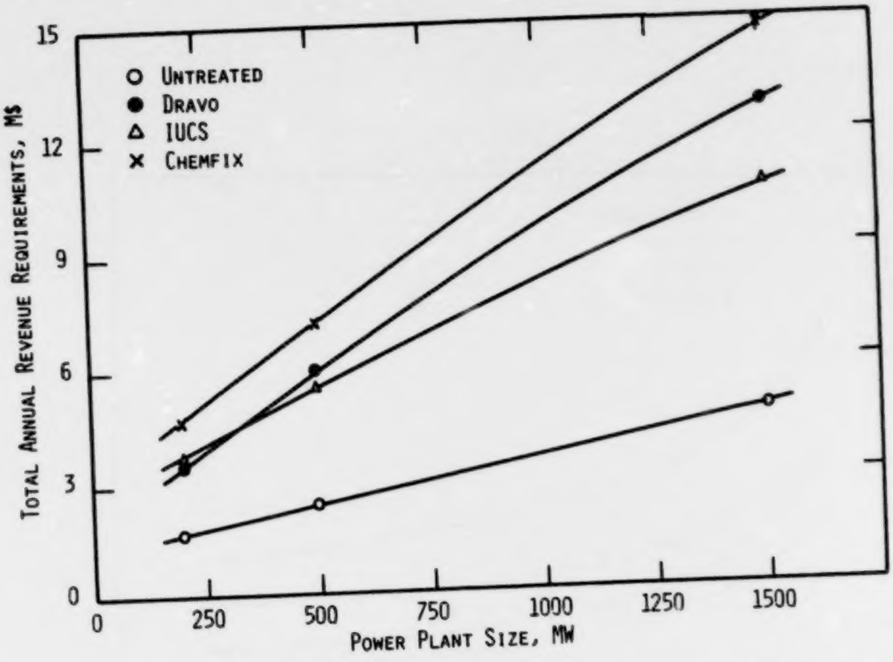

Figure 20. All processes. Effect of power plant size on total annual revenue requirements. Existing plant with 20-yr remaining life.

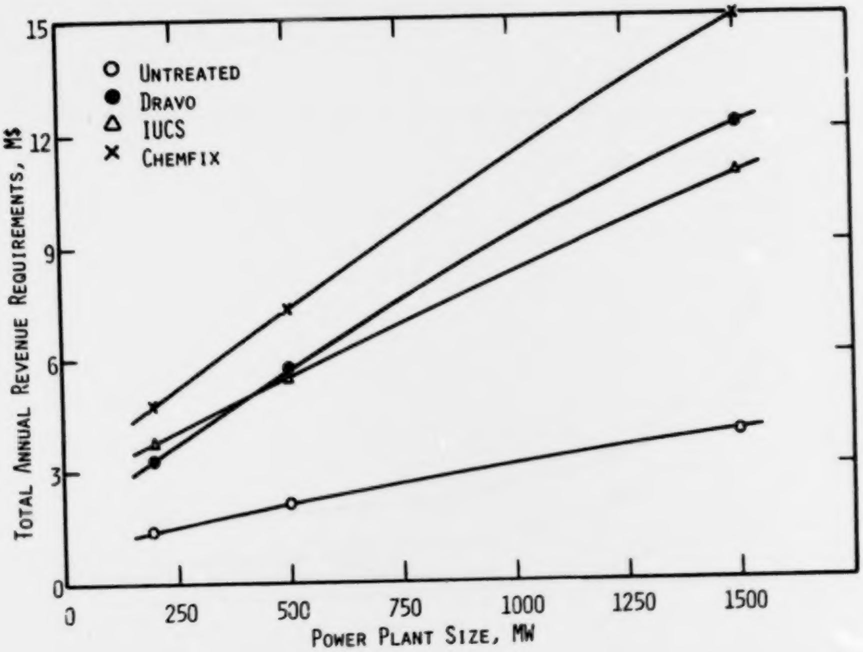

Figure 21. All processes. Effect of power plant size on total annual revenue requirements. Existing plant with 15-yr remaining life.

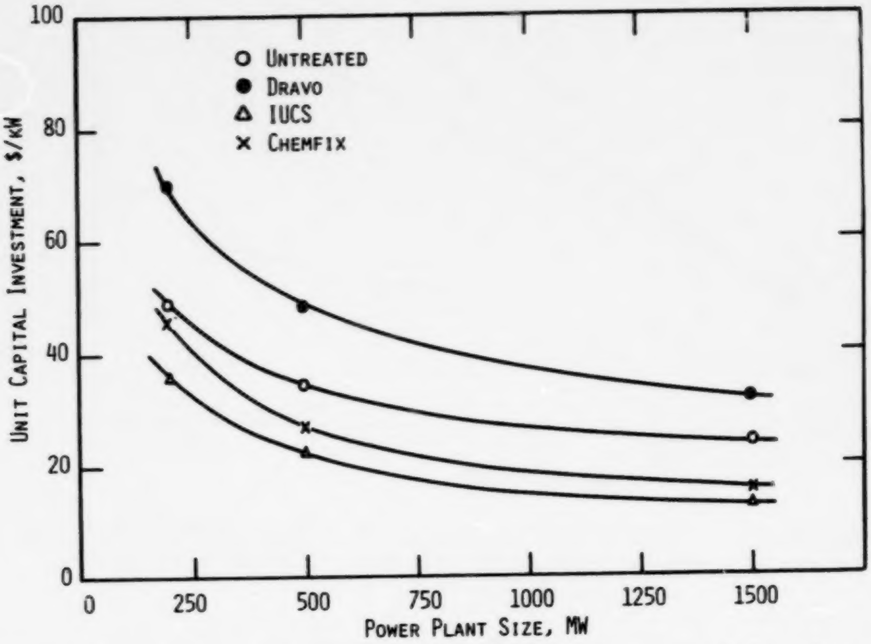

Figure 22. All processes. Effect of power plant size on unit capital investment. New plants.

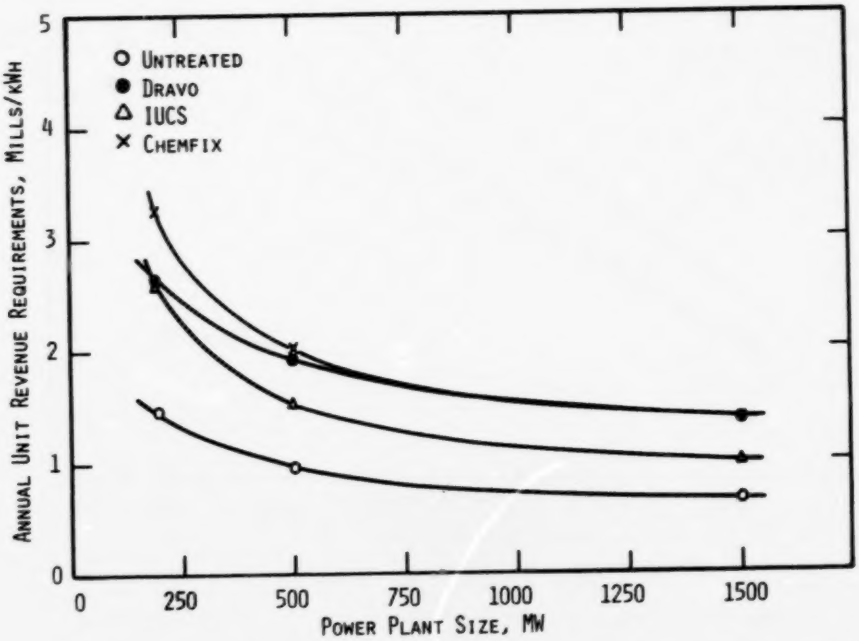

Figure 23. All processes. Effects of power plant size on annual unit revenue requirements. New plants.

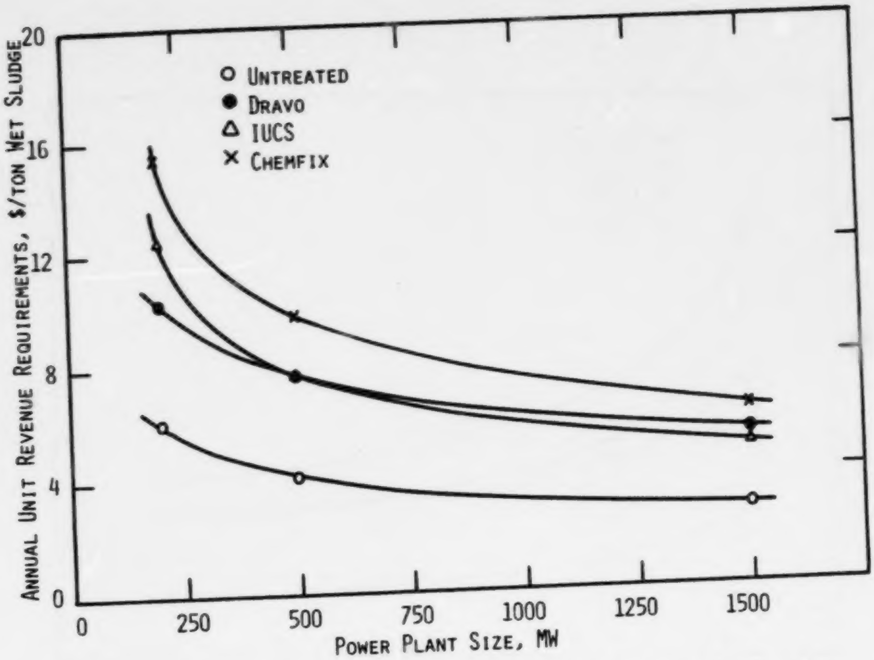

Figure 24. All processes. Effect of power plant size on annual unit revenue requirements. New plants.

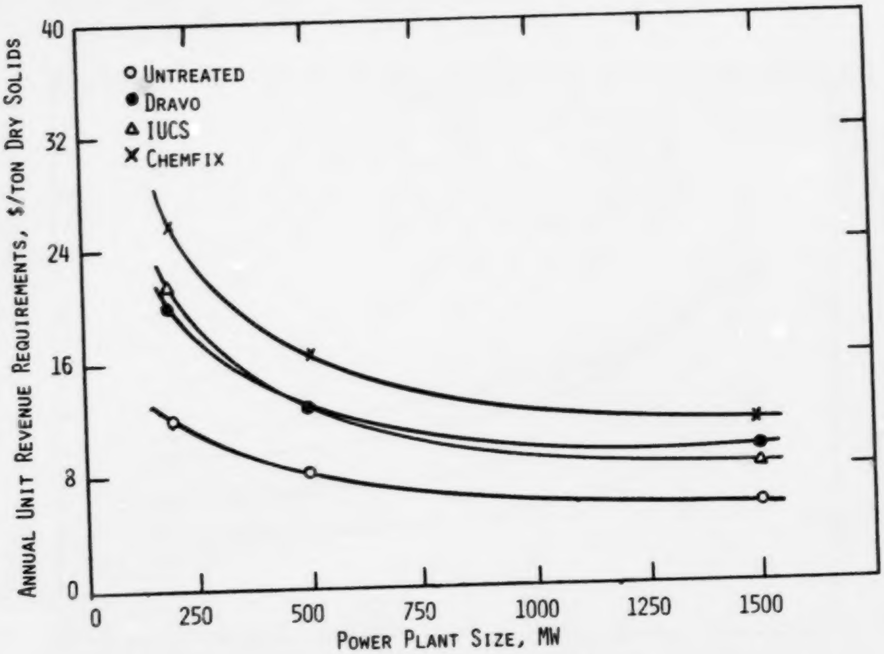

Figure 25. All processes, Effect of power plant size on annual unit revenue requirements. New plants.

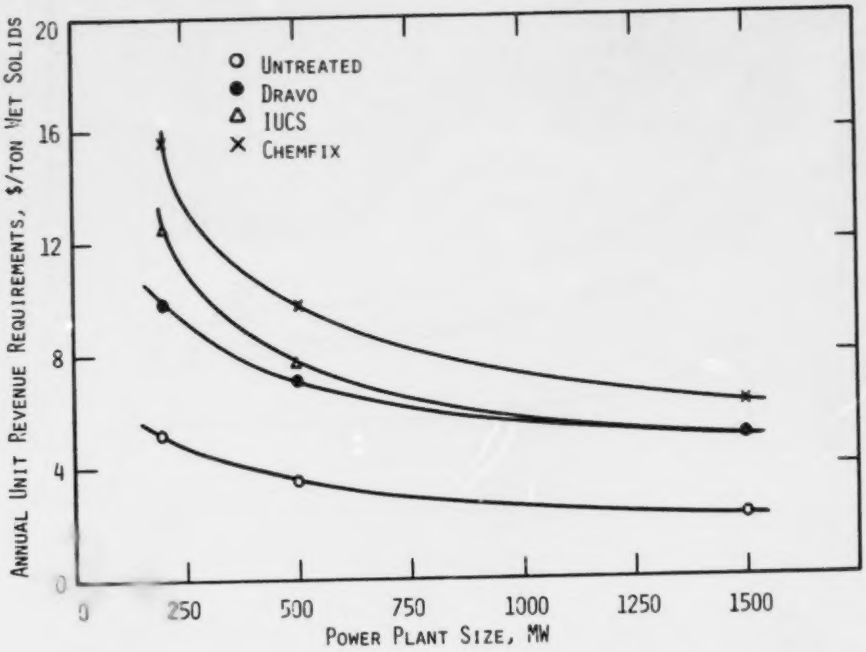

Figure 26. All processes, Effect of power plant size on annual unit revenue requirements. Existing plant with 25-yr remaining life.

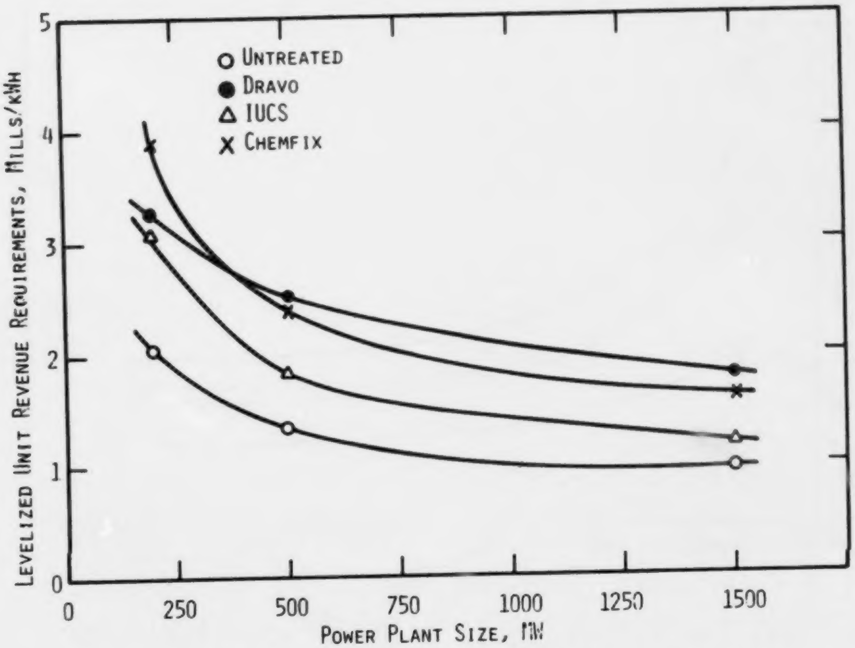

Figure 27. All processes. Effect of power plant size on levelized unit revenue requirements. New plants.

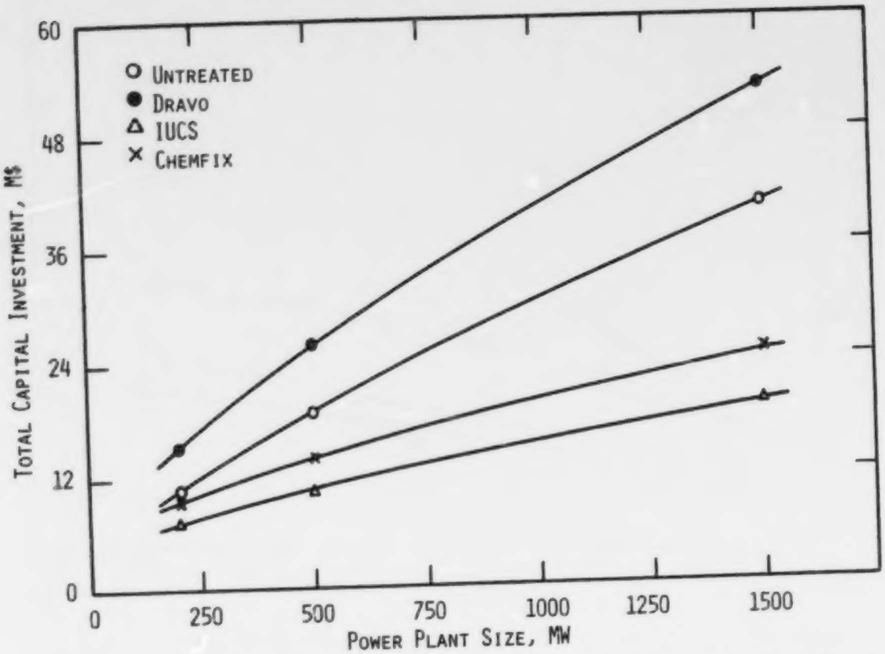

Figure 28. All processes. Effect of power plant size on total capital investment. New plant, operating constant 5,000 hr/yr throughout its 30-yr life.

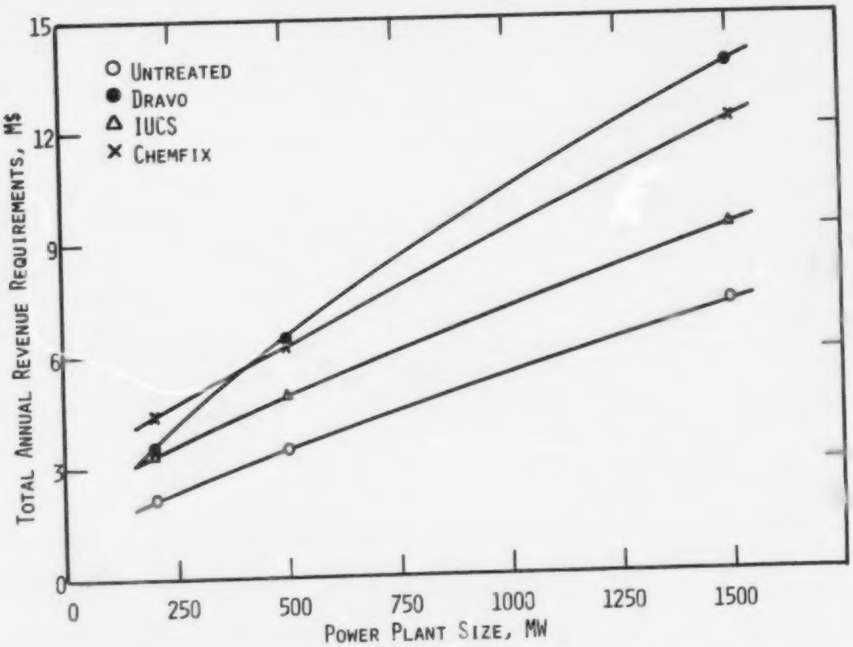

Figure 29. All processes. Effect of power plant size on total annual revenue requirements. New plant operating constant 5,000 hr/yr throughout its 30-yr life.

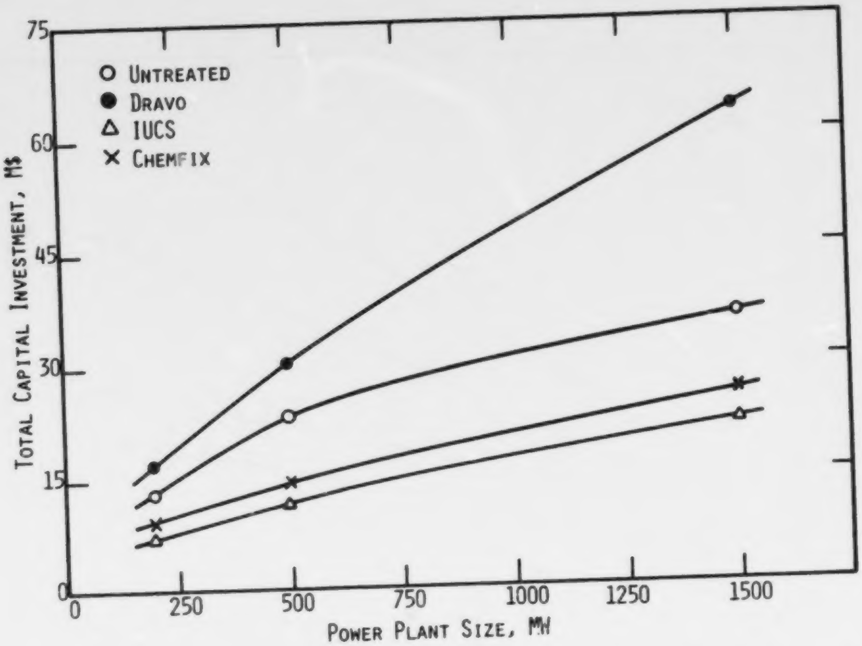

Figure 30. All processes. Effect of power plant size on total capital investment. New plant operating constant 7,000 hr/yr throughout its 30-yr life.

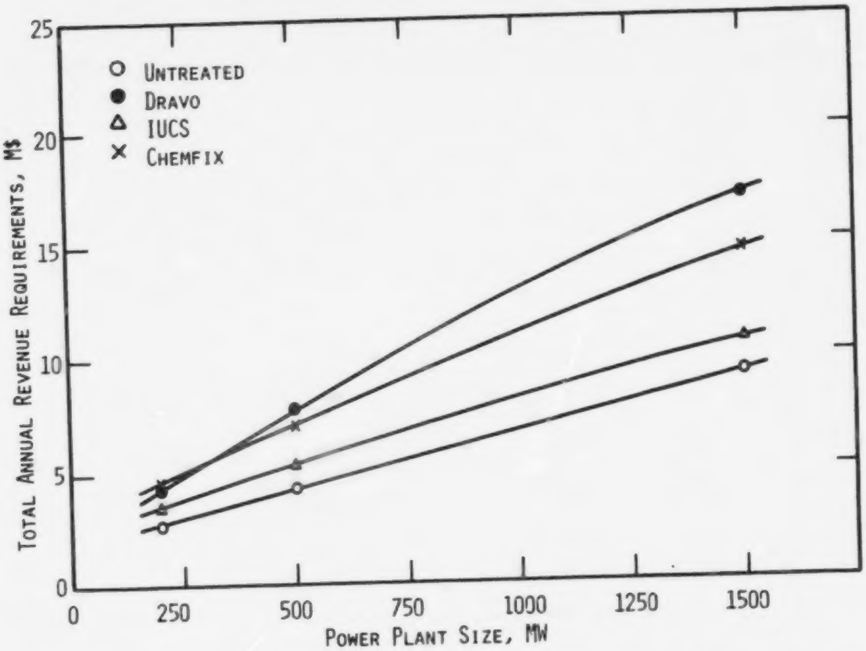

Figure 31. All processes. Effect of power plant size on total annual revenue requirements. New plant, operating constant 7,000 hr/yr throughout its 30-yr life.

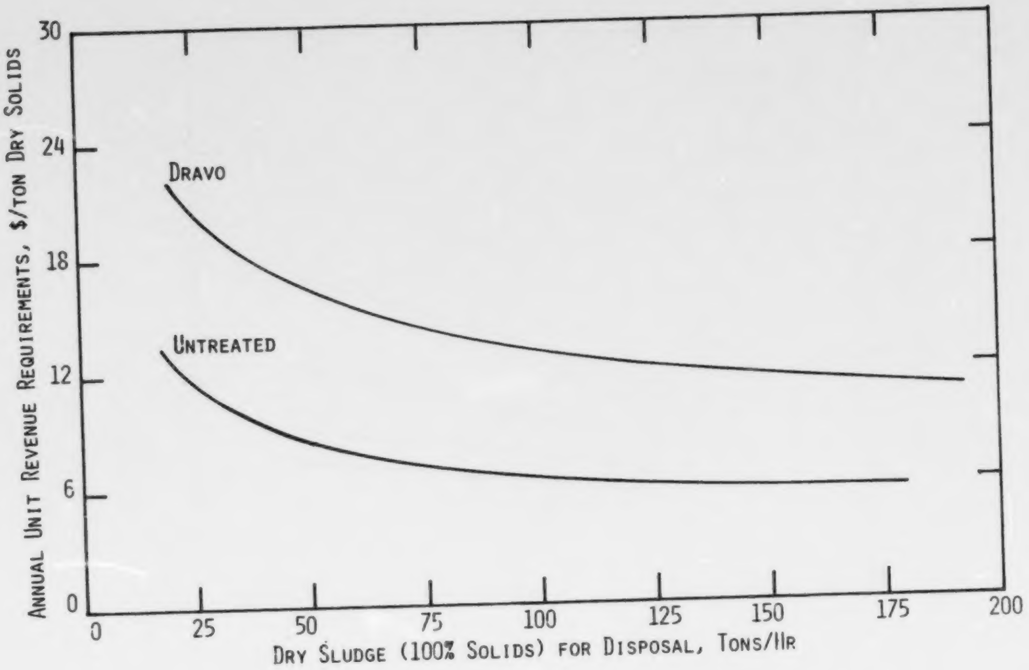

Figure 32. Untreated disposal and Dravo processes. Effect of sludge rate on annual unit revenue requirements.

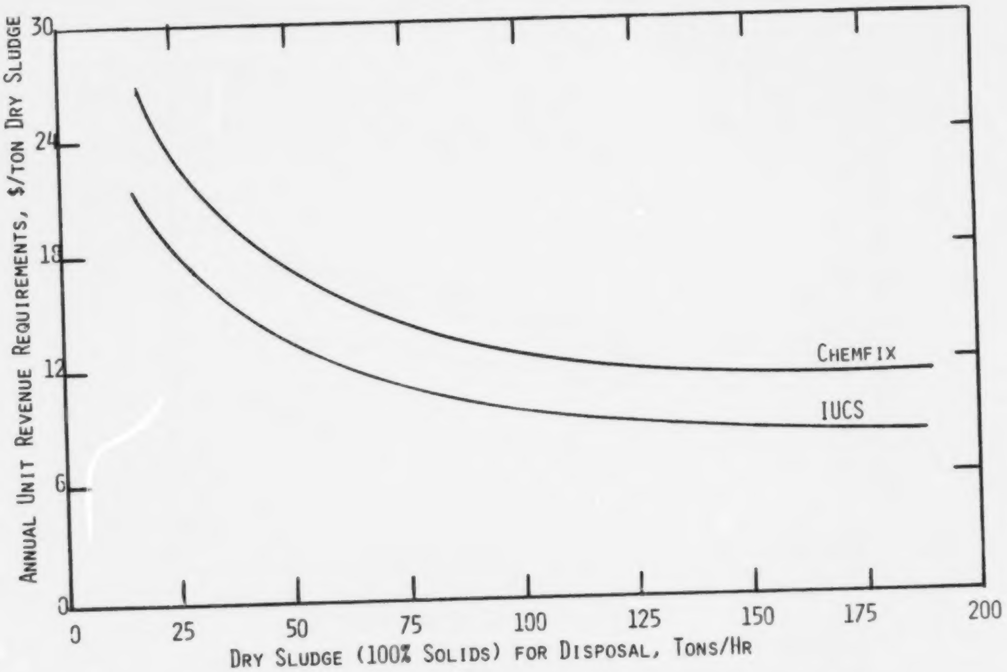

Figure 33. IUCS and Chemfix processes. Effect of sludge rate on annual unit revenue requirements.

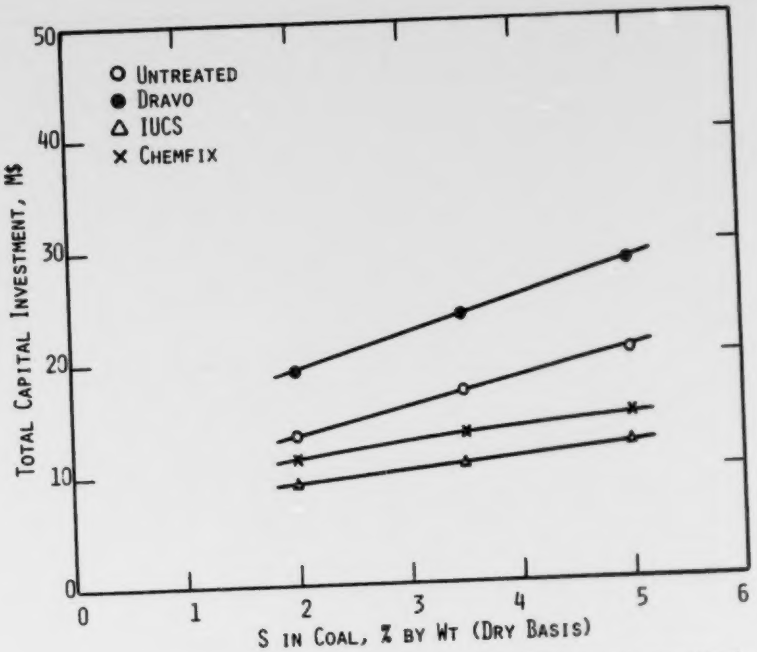

Figure 34. All processes. Effect of S content of coal on total capital investment. New 500-MW plant.

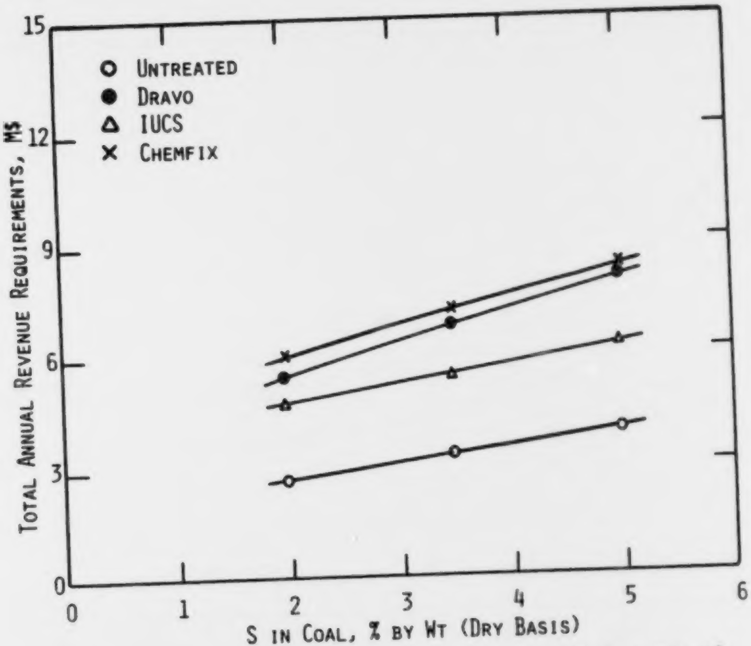

Figure 35. All processes. Effect of S content of coal on total annual revenue requirements. New 500-MW plant.

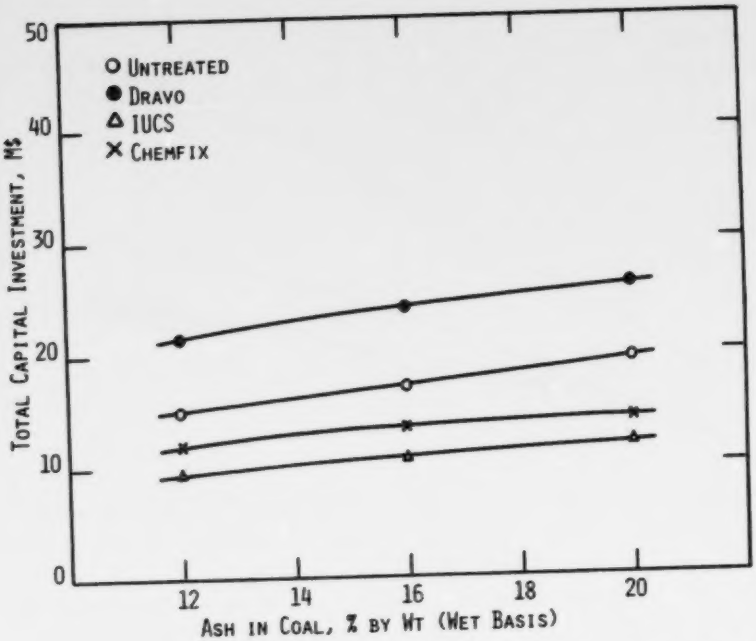

Figure 36. All processes. Effect of ash in coal on total capital investment. New 500-MW plant.

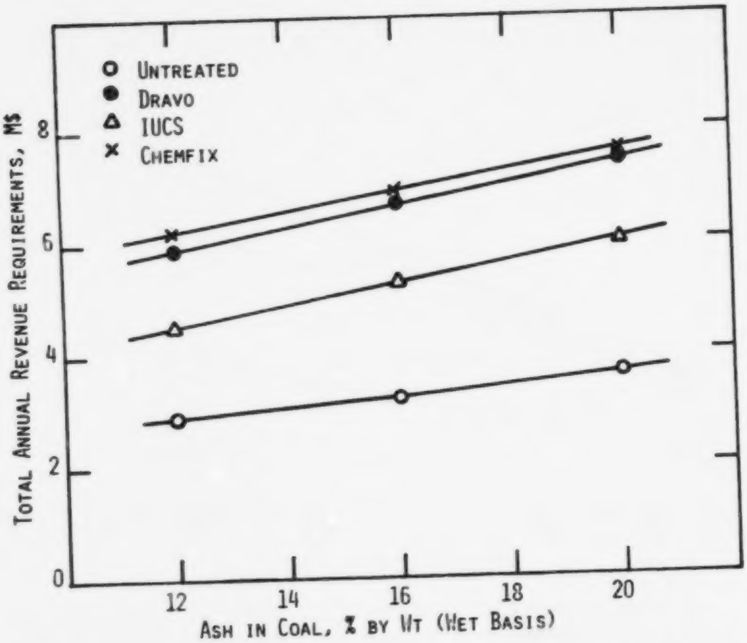

Figure 37. All processes. Effect of ash in coal on total annual revenue requirements. New 500-MW plant.

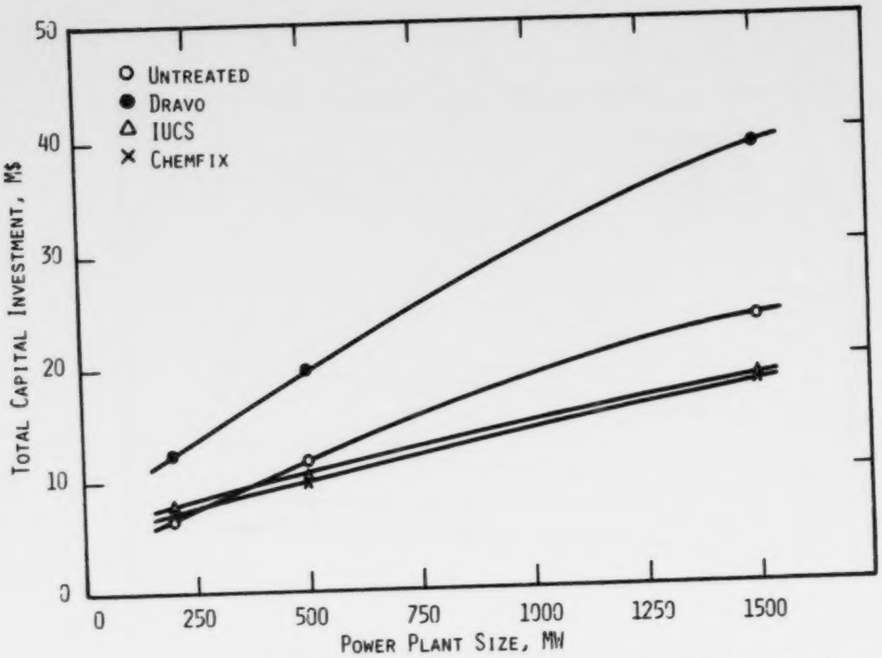

Figure 38. All processes. Effect of size of power plant having a separate ash disposal system on total capital investment for sludge disposal systems. New plants.

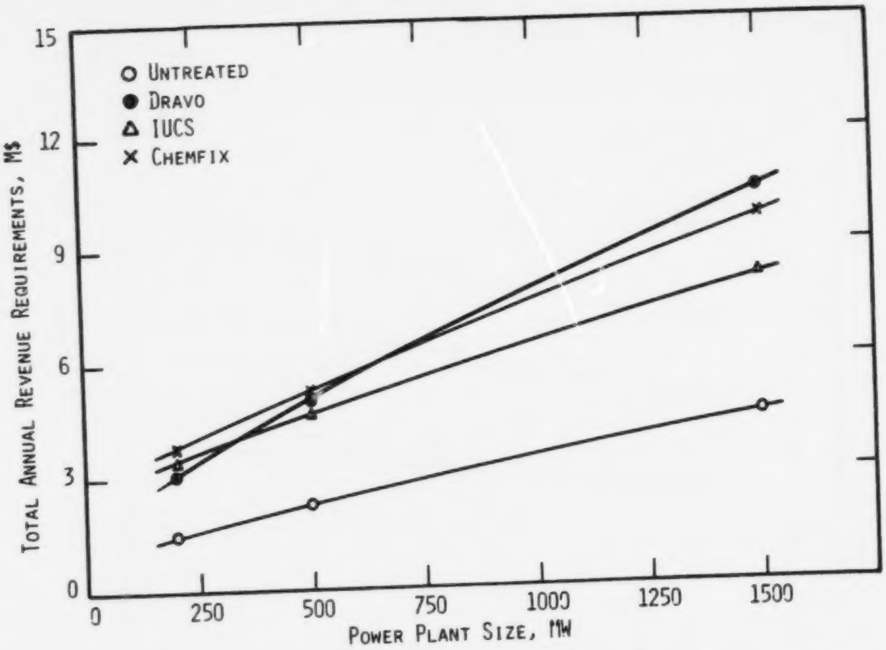

Figure 39. All processes. Effect of size of power plant having a separate ash disposal system on total annual revenue requirements for sludge disposal systems. New plants.

Distance to Disposal Site

Estimates were made for case variations in which the distance from the scrubber facilities was increased over the basic premise of 1 mi. Figures 40 and 41 show the variation with distance on total capital investment and annual revenue requirements. Transport lines (rubber-lined piping) are used for sludge transport in the untreated, Dravo, and Chemfix cases. Trucks are used for transport of material for landfill using the IUCS process. Figures 42 and 43 show the effects of sludge transport mode on total capital investment and annual revenue requirements (untreated sludge) for the range of disposal distances. Transport by truck is the least expensive capital investment method of transporting sludge at all distances (Figure 42). The distance to the disposal site determines if the solids content of the sludge should be increased in a thickener before pumping to the pond. Above a distance of about 3 mi, the capital investment of a system for pumping a 15% solids slurry is less than that of a system for pumping a 35% solids slurry (Figure 42).

Plant Remaining Life

The remaining life of a power plant when the FGD and sludge disposal system is installed has an effect on total capital investment and annual revenue requirements. An older plant that operates a shorter period of time will require a smaller acreage for the disposal pond or landfill. Capital charges are higher than that of a new plant due to depreciation. Figures 44-49 show the relationship between plant remaining life and the total capital investment and annual revenue requirements.

Optimum Pond Cost

A computer program was used for calculating optimum pond construction cost with respect to depth and area. For each sludge disposal rate, the optimum pond was estimated based on 1979 costs. Also, the amount of excavation and total depth and acreage of the pond were calculated. Since land availability may limit the acreage on which a pond can be constructed, estimates were made for the two systems (untreated ponding and Dravo process) that use ponds for disposal, with pond acreage held at 50 and 75% of optimum. These results are shown in Figures 50-53 as functions of new plant sizes. Pond construction cost is greatly increased (122% for Dravo 500-MW plant) when the acreage is limited (50% of optimum), thereby increasing the excavation depth over optimum.

Settled Sludge Density

The base case assumption for settled sludge density in the disposal pond is 50% solids. There may be cases in which settled sludge density is more or less than 50% solids. Two case variations are included for untreated pond disposal for settled densities of 40% solids and 60% solids. Figures 54 and 55 show the effect of settled density on total capital investment and annual revenue requirements for disposal of untreated sludge from a new 500-MW power plant.

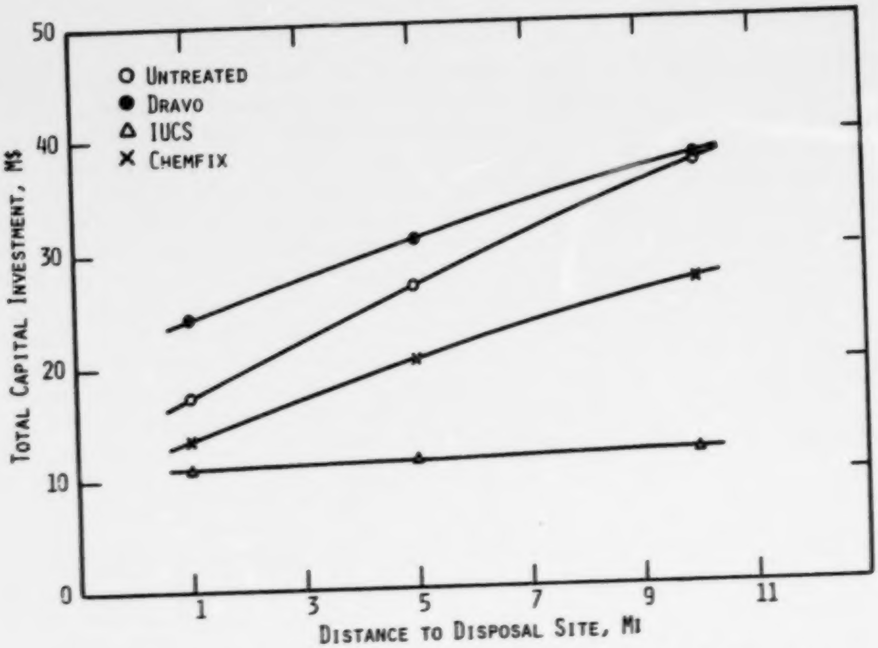

Figure 40. All processes. Effect of distance to disposal site on total capital investment. New 500-MW plant.

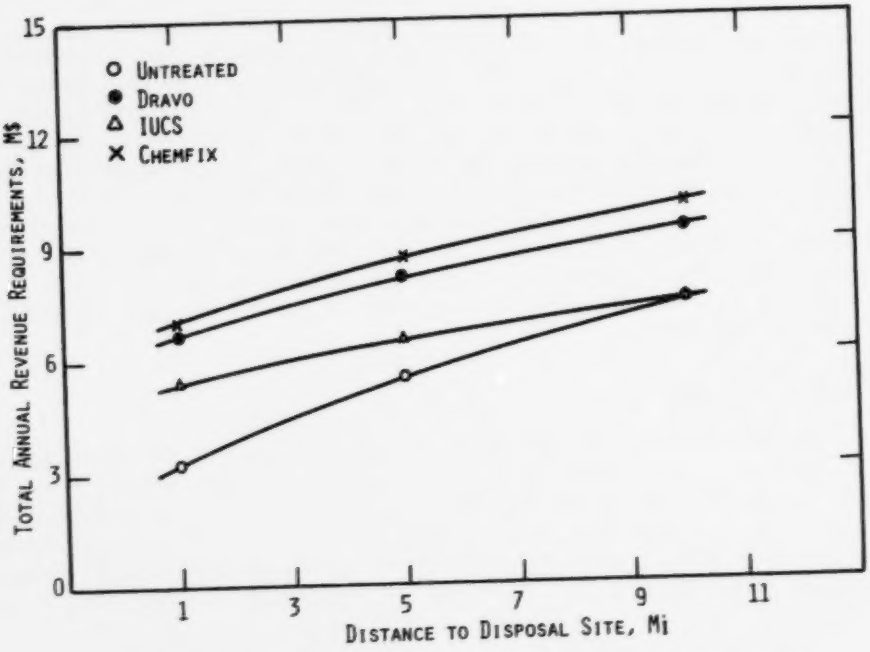

Figure 41. All processes. Effect of distance to disposal site on total annual revenue requirements. New 500-MW plant.

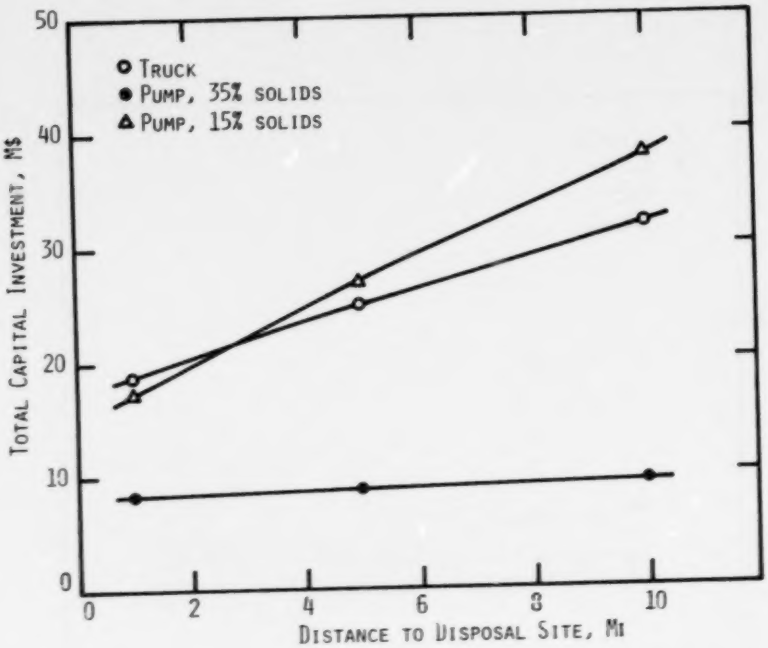

Figure 42. Untreated process. Effect of distance to disposal site and mode of transport on total capital investment. New 500-MW plant.

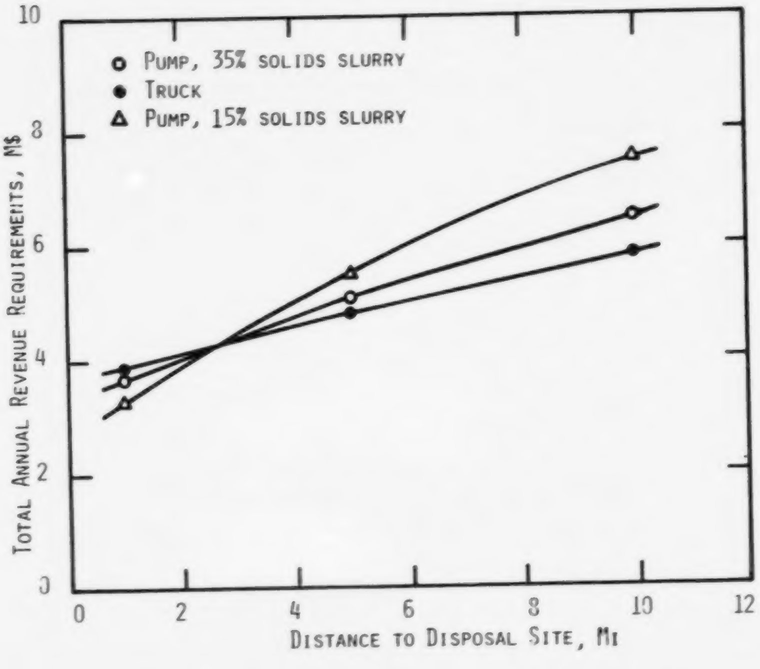

Figure 43. Untreated process. Effect of distance to disposal site and mode of transport on total annual revenue requirements. New 500-MW plant.

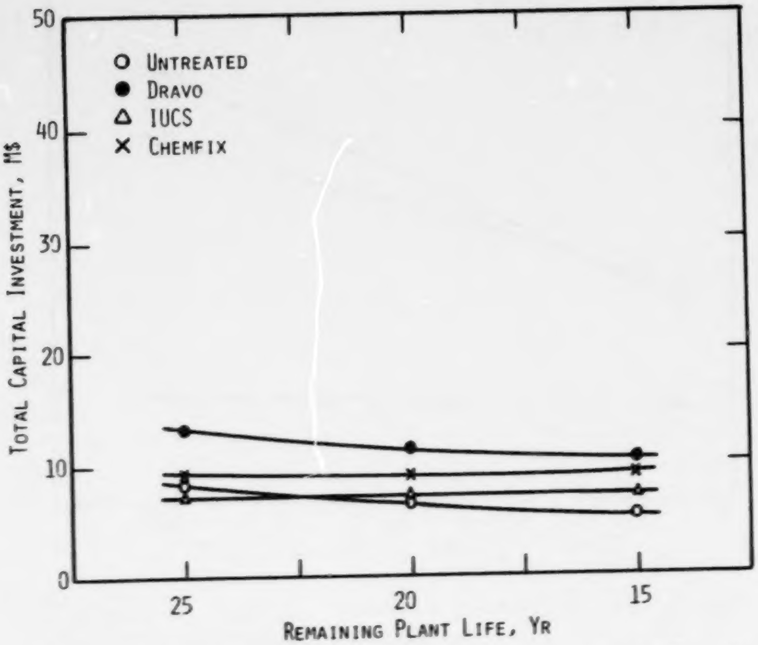

Figure 44. All processes. Effect of remaining plant life on total capital investment. 200-MW plant.

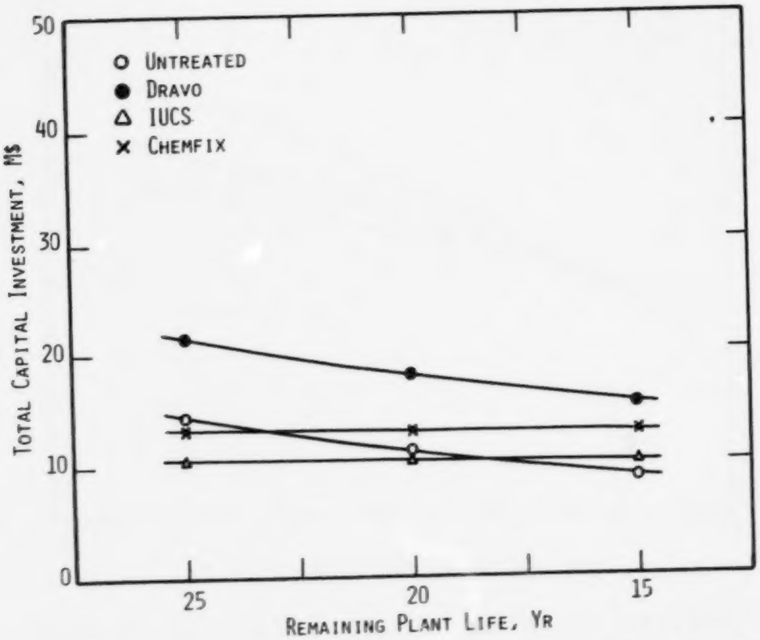

Figure 45. All processes. Effect of remaining plant life on total capital investment. 500-MW plant.

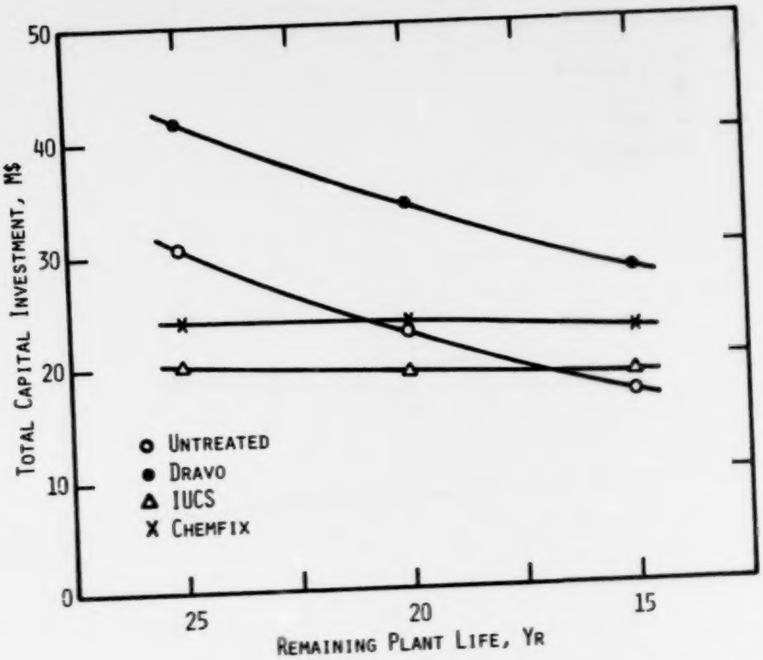

Figure 46. All processes. Effect of remaining plant life on total capital investment. 1500 MW-plant.

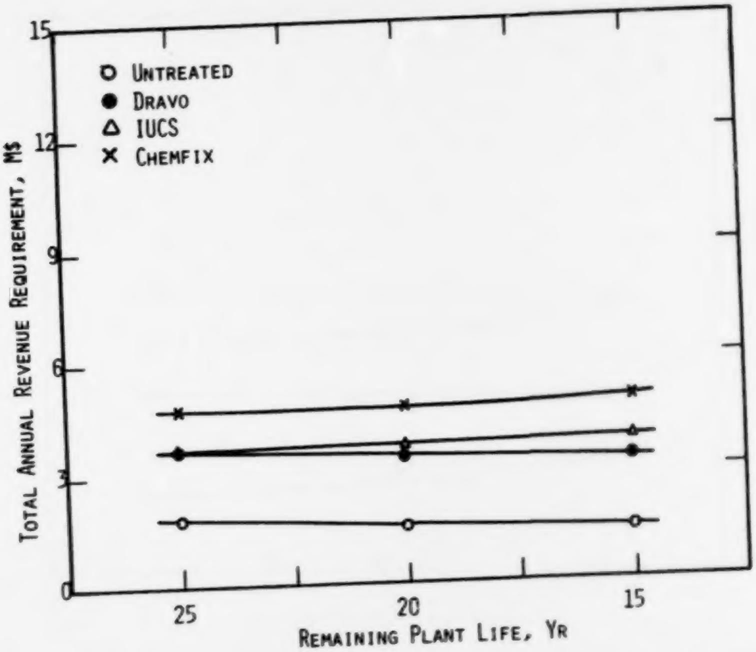

Figure 47. All processes. Effect of remaining plant life on total annual revenue requirement. 200-MW plant.

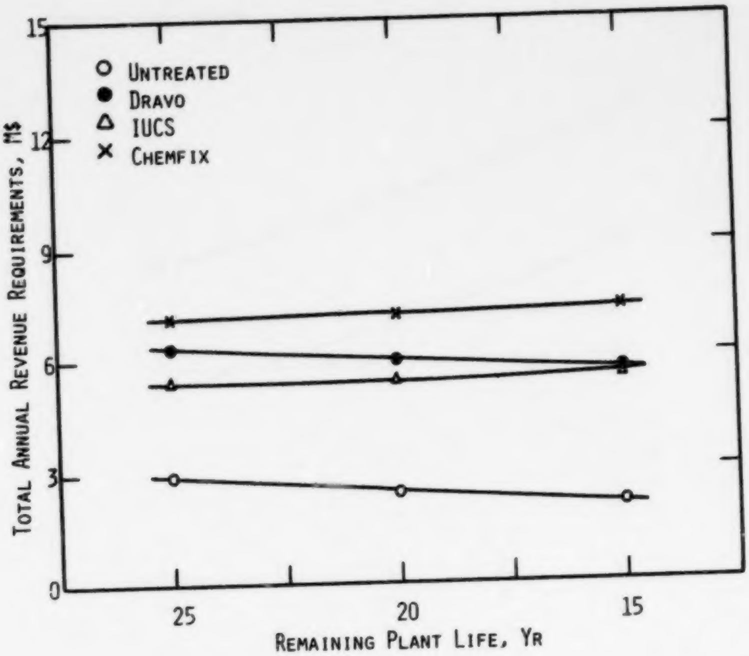

Figure 48. All processes. Effect of remaining plant life on total annual revenue requirements. 500-MW plant.

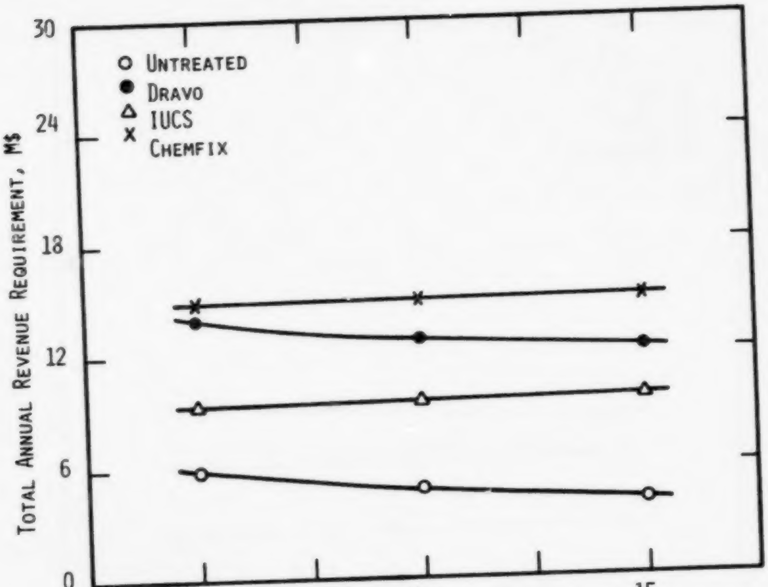

Figure 49. All processes. Effect of remaining plant life on total annual revenue requirement. 1500-MW plant.

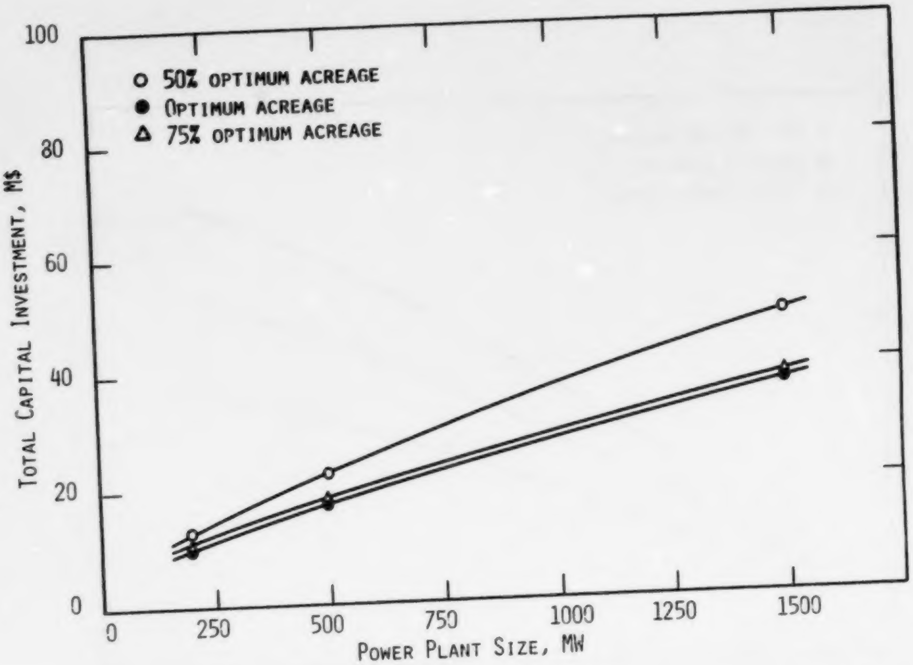

Figure 50. Untreated process. Effect of available pond acreage and power plant size on total capital investment.

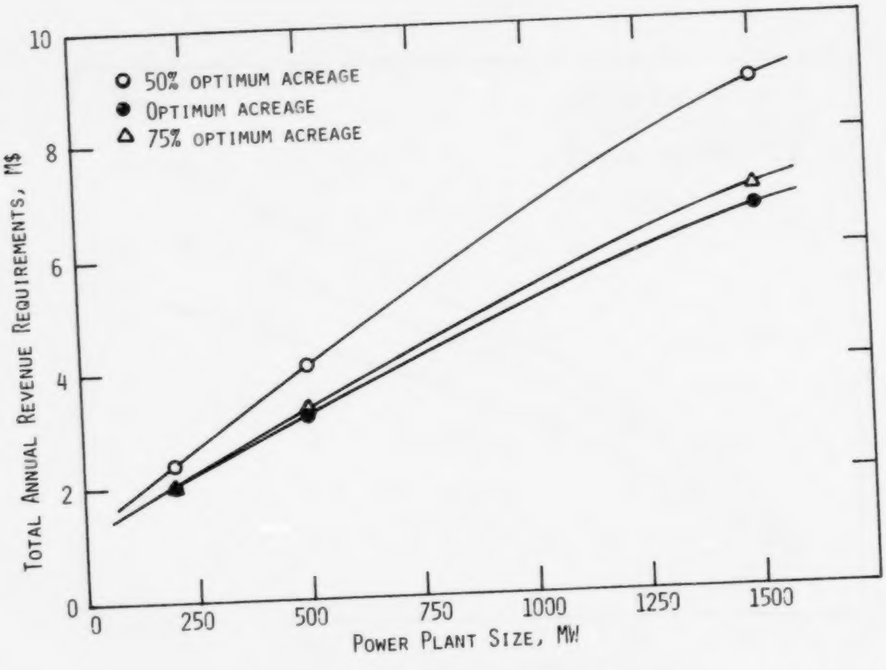

Figure 51. Untreated disposal. Effect of available pond acreage and power plant size on total annual revenue requirements.

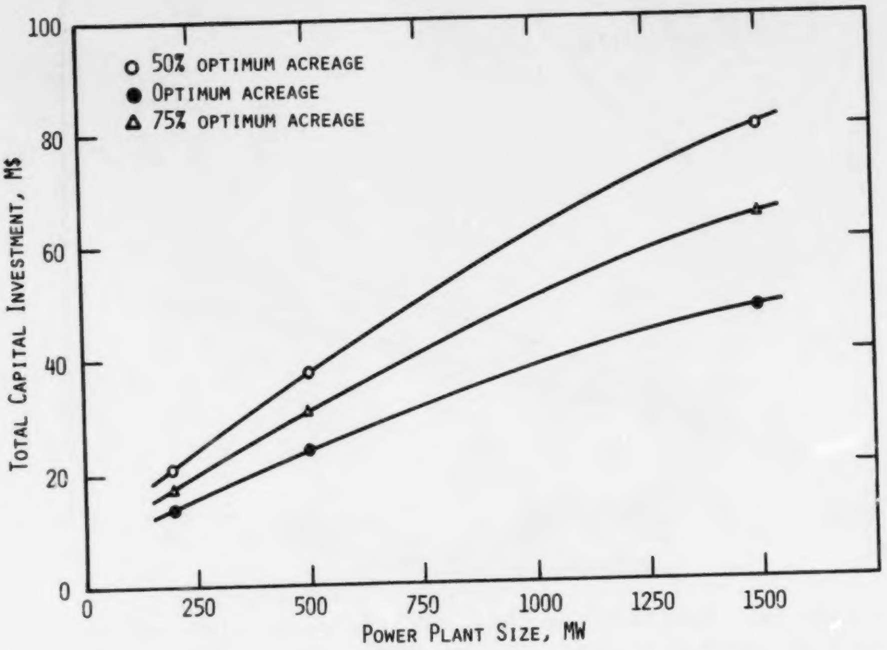

Figure 52. Dravo process. Effect of available pond acreage and power plant size on total capital investment.

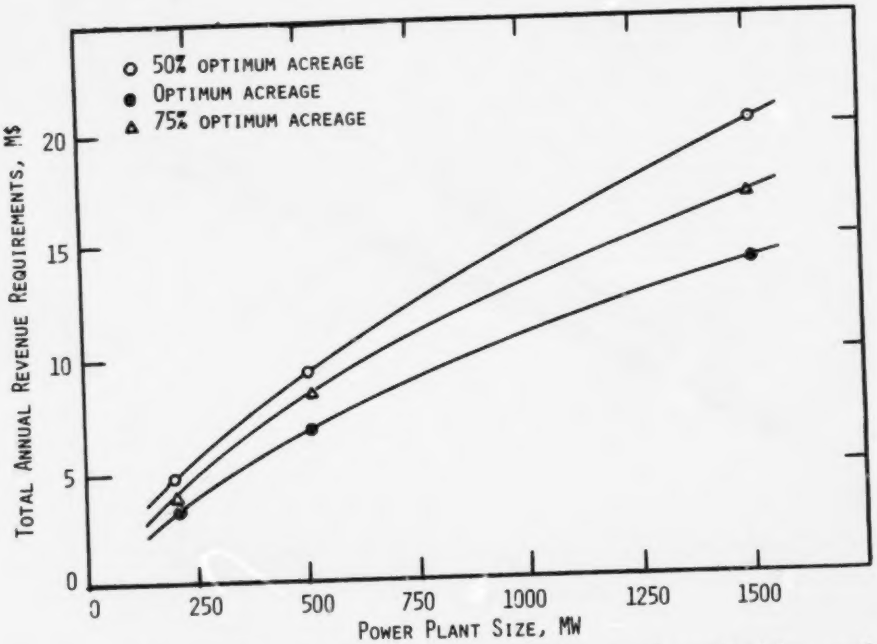

Figure 53. Dravo process. Effect of available pond acreage and power plant size on total annual revenue requirements.

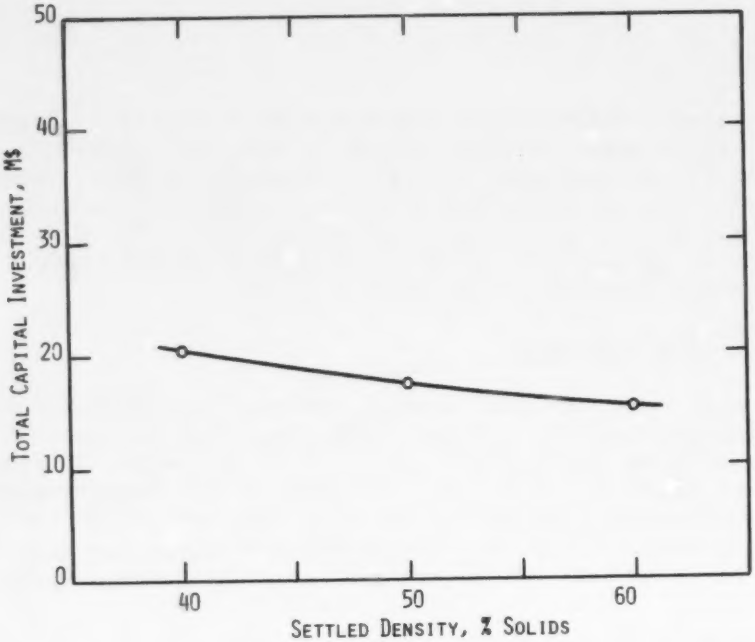

Figure 54. Untreated process. Effect of settled density in disposal pond on total capital investment. New 500-MW plant.

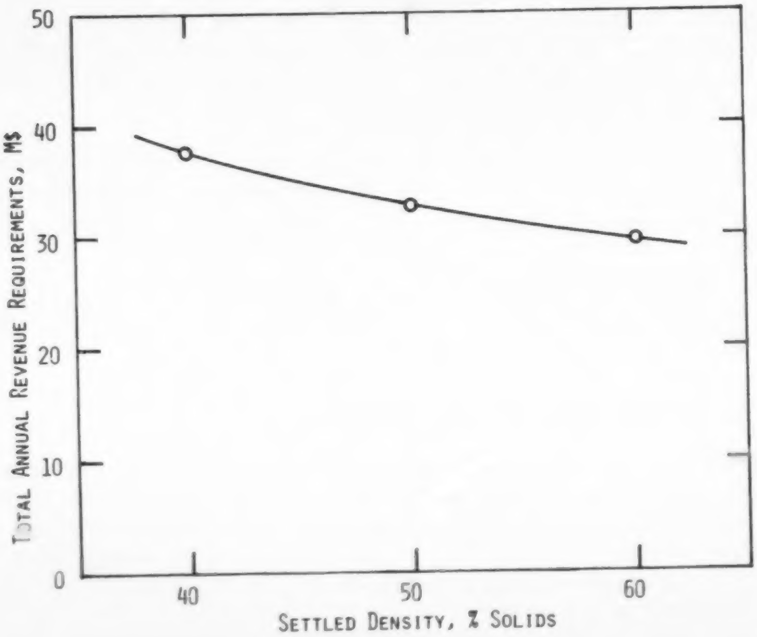

Figure 55. Untreated process. Effect of settled density in disposal pond on total annual revenue requirements. New 500-MW plant.

Pond Liners

The cost of constructing a disposal pond is partially dependent upon the type of liner used. Figures 56 and 57 show the relationship between cost of pond lining and total capital investment and total annual revenue requirements. The estimates are for direct ponding of untreated (15% solids slurry) sludge from a new 500-MW (base case) plant. The liner costs used in these estimates represent a range of costs obtained from vendors for synthetic lining materials (Hypalon, polyethylene, etc.).

Stabilization Additive Rate

A standard rate for stabilization additive was specified by each of the three process companies (Dravo, IUCS, Chemfix). One set of case variations considered was for additive rates above and below the standard rates. The effect of these variations on the total capital requirements and annual revenue requirements is shown in Table 37. The rate deviations considered were based on changes that have equivalent effects on the stabilization process (time for stabilization, required dewatering, handling properties, etc.).

Ponding versus Landfill - Dravo Process

Estimates were made for a variation of the Dravo process that involves intermediate ponding of treated sludge in a small 2-wk-capacity holding pond for curing (15-30 days) before transport by truck to a landfill for disposal. Three small ponds located near the scrubber facilities are used for a continuous, cyclic operation: filling, curing, and emptying. A comparison of this disposal alternative with the base Dravo process of ponding is shown below. (The quantity--new 500-MW plant--of sludge being treated is the same for both alternatives.)

Case variation	Total capital investment, k$	Annual revenue requirements, k$
Intermediate ponding and trucking to landfill	12,670	6,620
Standard Dravo ponding	24,114	6,701

Truck versus Pipeline Transport - Chemfix

All cases for the Chemfix process involve the pipeline transport of 35% solids slurry from a thickener near the scrubber facilities to the disposal area where the final stages of treatment by the Chemfix process are applied. The 35% solids slurry is filtered to form a material containing 60% solids and mixed with fixation additives before placement and compaction in a landfill with earthmoving equipment.

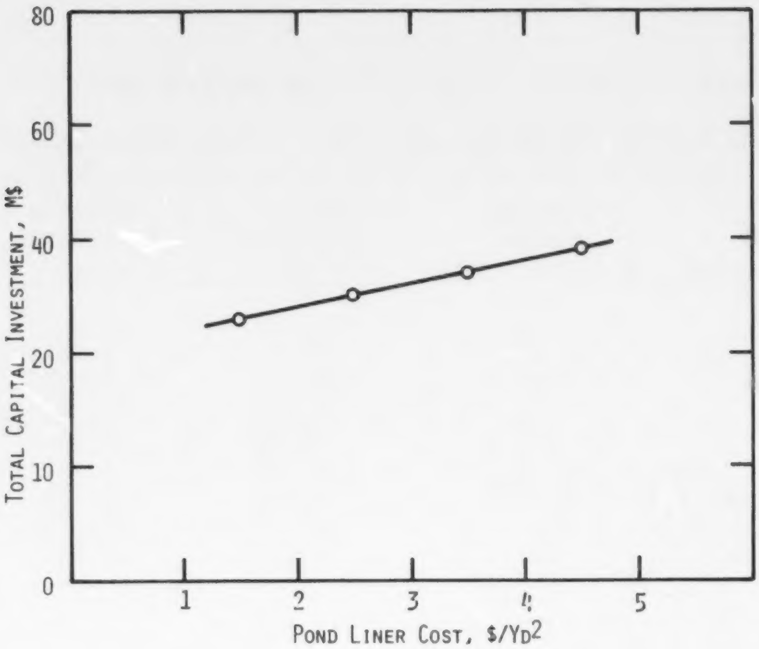

Figure 56. Untreated process. Effect of unit cost of pond liners on total capital investment. New 500-MW plant.

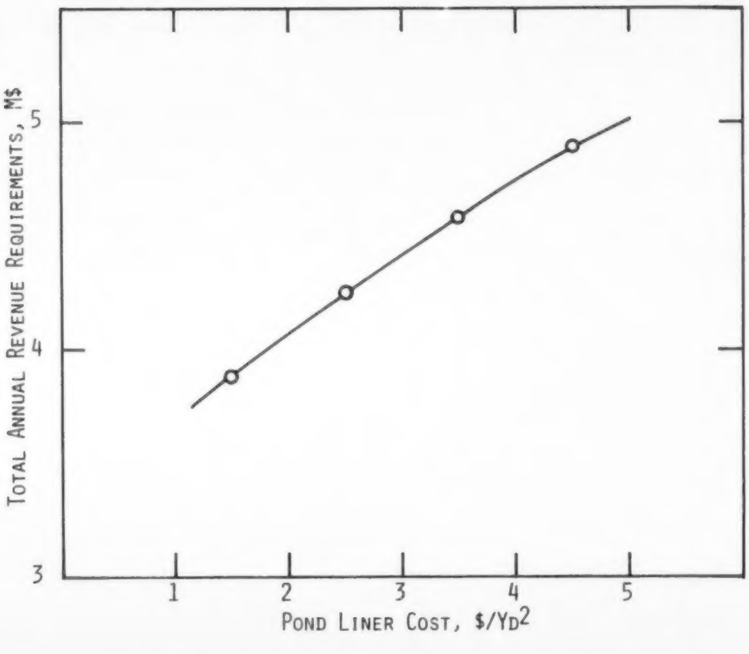

Figure 57. Untreated process. Effect of unit cost of pond liners on total annual revenue requirements. New 500-MW plant.

TABLE 37. EFFECT OF STABILIZATION ADDITIVE RATE ON TOTAL CAPITAL INVESTMENT AND ANNUAL REVENUE REQUIREMENTS

Treated sludge process	Additive amount, % of dry solids	Capital investment,[a] k$	Revenue requirement,[a] k$
Dravo	5	23,120	6,052
Dravo	7[b]	24,114	6,701
Dravo	10	25,209	7,577
IUCS	3	10,302	4,994
IUCS	4[b]	10,717	5,291
IUCS	5	10,748	5,511
Chemfix	7[b,c]	13,531	6,988
Chemfix	12	14,757	10,089
Chemfix	22	16,270	13,651

a. Base case with additive amount variations.
b. Base case additive amount.
c. Fixation will not occur below this amount of additive.

An alternative of treating the filter cake at the scrubber facilities and trucking the treated sludge to the disposal area was also considered as a case variation. The following costs are for the Chemfix base case and the truck transport variation.

Case variation	Total capital investment, k$	Annual revenue requirements, k$
Truck transport	11,740	6,698
Pipeline transport	13,531	6,988

CONCLUSIONS AND RECOMMENDATIONS

The conclusions derived from data generated in this study are divided into three categories. One category is for conclusions concerning the economic comparisons of disposal process alternatives. The second category deals with the effects of case variations for each of the disposal process alternatives. The third category summarizes the recommendations for future studies needed to provide a complete evaluation of sludge disposal options. The three categories are discussed in this section of the report.

ECONOMIC COMPARISONS OF PROCESS ALTERNATIVES

Economic comparisons are significant among both capital investments and revenue requirements for the four disposal process alternatives. The following is a listing of conclusions that can be derived from the comparison of costs.

Capital Investments

1. The disposal alternative for a new 500-MW plant (base case) requiring the lowest capital investment is the IUCS process for fixation and landfill disposal. The Dravo process for treatment and pond disposal was the most capital intensive alternative.

2. The remaining life of a power plant has a significant effect on the relative ranking of capital investment requirements for two of the four disposal alternatives being evaluated (untreated and Dravo). For a 500-MW plant with 15 yr remaining life (otherwise base case conditions), the untreated pond disposal alternative is the least expensive, followed by the IUCS process. The Dravo process is again, as for the base case conditions, the most expensive. These results are illustrated in Figures 16-18 and 44-46.

3. The ash and S contents of the coal burned have a significant effect on the capital investment required for the disposal system. The relative ranking of the four alternatives, however, remains unchanged for the concentration ranges considered (Figures 34-37).

4. As would be expected, the cost of disposal systems for 500-MW plants with sludge containing no flyash are considerably less expensive, because of the smaller quantities of material to be processed, than the cost of systems in which the flyash is removed with the calcium

sludge. The relative ranking of capital investments for the four alternatives is the same as for base case systems. The ranking, however, is changed for the 200-MW (no flyash) plants with the untreated pond disposal option being the least expensive. This change in rank reflects the effect of variation in economy of scale among the systems on capital investments (Figures 38-39).

5. The distance to the disposal site greatly increases the capital investments for the untreated, Dravo, and Chemfix alternatives. These increased values are primarily a result of the additional cost for pipelines and pumps. The capital investment for the IUCS system is affected very little by the distance to the disposal site because little additional equipment is needed. Operating costs are increased significantly (see Figures 40-43). Trucks are used for sludge transport.

6. Variations in fixation additive amounts have little effect on capital investments for the IUCS and Dravo processes. Equivalent (additive amount variations having similar effect on degree and rate of fixation) variations for the Chemfix process cause the capital investment requirements to be significantly changed.

7. Case variations for disposal of sludge in ponds constructed on constrained acreage (less than optimum based on land and construction costs) have higher total capital investments than the optimum (base case) pond acreage. These variations show the potential problems for plants with a limited quantity of land available for ponding (therefore forced to make ponds deeper with higher dikes).

Annual Revenue Requirements

1. Base case revenue requirements for a new 500-MW plant are lowest for the untreated ponding alternative followed by the IUCS process. The alternative requiring the highest annual revenue is the Chemfix process.

2. The remaining life of a power plant affects the annual revenue requirements for the disposal alternative because of lower depreciation and capital changes. The relative ranking of revenue requirements for the four disposal alternatives is unchanged for existing 500-MW plants from that of a new 500-MW plant. These rankings, however, change for 200-MW plants. Specific cost data can be obtained from Appendix A and Figures 47-49.

3. The quantity of sludge for disposal affects the annual revenue requirements such that the relative rankings for the four alternatives may change, especially for smaller quantities. Variations in coal composition (S and ash) and the exclusion of flyash in the sludge illustrate these effects.

4. The distance to the disposal site has a significant effect on total annual revenue requirements as illustrated in Figures 41 and 43. For 500- and 1500-MW plants using the untreated process, the least expensive alternative is to pump the 15% scrubber system effluent directly to the disposal pond and the most costly method of transportation is to use trucks to haul dewatered sludge. For 200-MW plants, the opposite of the above is true and trucking is the least expensive alternative and pipeline transport of 15% solids slurry is the most expensive.

EFFECTS OF CASE VARIATIONS FOR EACH ALTERNATIVE

The effects of case variations on total capital investments and annual revenue requirements for each disposal alternative are shown in Tables 38-41.

Untreated Disposal

Capital Investment--

A major portion of the capital investment required for untreated sludge disposal cases is for the disposal pond. Any variation causing a significant change in the quantity of sludge to be ponded results in considerable change in total capital investment requirement. Changes having this effect include the remaining life of the plant, coal composition, scrubbing process, and the density of settled sludge in the disposal pond. An example of this effect as shown in Table 38 is the 20% increase in capital investment for a new 500-MW plant burning 5% S coal as compared to the base case 3.5% S coal.

The use of synthetic pond liners for disposal ponds results in an increase in total capital investment for a new 500-MW plant over the base case. For the range of costs for pond liners considered ($1.50-$4.50/yd^2), capital investment as compared to the base case increases from about 22 to 55%. The capital investment is 16% less for the case with an unlined disposal pond than that for the base case. The capital investment required for untreated ponding is significantly reduced for disposal sites located in excess of about 3 mi from the scrubber facilities if the slurry is dewatered to 35% solids with a thickener before pipeline transport to the pond. Capital investments are 46-52% less for the disposal of untreated, dewatered (60% solids) sludge in a landfill following truck transport than for the base system for pond disposal. The distance to the disposal site has little effect in capital investments for these systems.

Revenue Requirements--

Annual revenue requirements for a 200-MW and a 1500-MW plant are 61 and 206% of annual revenue requirements for the base case. These values illustrate the economy of scale for untreated disposal systems. The annual revenue requirements for case variations involving distances to the disposal site are 69% (5-mi case) and 129% (10-mi case) more than the base case annual revenue requirements. If the slurry is thickened (35% solids) before pumping to the disposal pond, the annual revenue requirements are less for

TABLE 38. EFFECT OF CASE VARIATIONS ON TOTAL CAPITAL INVESTMENT AND ANNUAL REVENUE REQUIREMENTS - UNTREATED DISPOSAL

Variation from base case	Percent change from base case: Capital investment	Percent change from base case: Annual revenue requirement
200 MW new	-43	-39
200 MW existing, 25-yr remaining life	-51	-44
200 MW existing, 20-yr remaining life	-60	-51
200 MW existing, 15-yr remaining life	-68	-56
Existing, 25-yr remaining life	-15	-11
Existing, 20-yr remaining life	-34	-26
Existing, 15-yr remaining life	-49	-35
1500 MW new	112	106
1500 MW existing, 25-yr remaining life	76	78
1500 MW existing, 20-yr remaining life	33	44
1500 MW existing, 15-yr remaining life	-13	21
12% ash in coal	-11	-12
20% ash in coal	10	10
2% S in coal	-22	-20
5% S in coal	20	18
200 MW, no flyash	-61	-54
No flyash	-34	-30
1500 MW, no flyash	37	39
5 mi to disposal	56	69
10 mi to disposal	117	129
Lime scrubbing process	6	-4
Clarify (35% solids) and pump 1 mi	7	13
Clarify (35% solids) and pump 5 mi	45	58
Clarify (35% solids) and pump 10 mi	83	97
Clarify, filter (60% solids) and truck 1 mi	-52	16
Clarify, filter (60% solids) and truck 5 mi	-49	50
Clarify, filter (60% solids) and truck 10 mi	-46	77
200 MW, constrained pond acreage (50% of optimum)	-26	-25
200 MW, constrained pond acreage (75% of optimum)	-41	-38
Constrained pond acreage (50% of optimum)	32	26
Constrained pond acreage (75% of optimum)	5	3
1500 MW, constrained pond acreage (50% of optimum)	184	174
1500 MW, constrained pond acreage (75% of optimum)	122	115
Pond settled density (40% solids)	17	14
Pond settled density (60% solids)	-12	-10
Unlined pond	-16	16
Synthetic pond lining ($1.50/yd^2)	22	18
Synthetic pond lining ($2.50/yd^2)	34	30
Synthetic pond lining ($3.50/yd^2)	45	40
Synthetic pond lining ($4.50/yd^2)	55	49

TABLE 39. EFFECT OF CASE VARIATIONS ON TOTAL CAPITAL INVESTMENT AND ANNUAL REVENUE REQUIREMENTS - DRAVO PROCESS

	Percent change from base case	
Variation from base case	Capital investment	Annual revenue requirement
200 MW new	-42	-46
200 MW existing, 25-yr remaining life	-45	-45
200 MW existing, 20-yr remaining life	-52	-48
200 MW existing, 15-yr remaining life	-58	-49
Existing, 25-yr remaining life	-11	-5
Existing, 20-yr remaining life	-24	-11
Existing, 15-yr remaining life	-36	-15
1500 MW new	100	113
1500 MW existing, 25-yr remaining life	72	106
1500 MW existing, 20-yr remaining life	41	90
1500 MW existing, 15-yr remaining life	16	81
12% ash in coal	-11	-12
20% ash in coal	8	11
2% S in coal	-20	-21
5% S in coal	18	20
200 MW, no flyash	-49	-54
No flyash	-18	-24
1500 MW, no flyash	61	56
5 mi to disposal	29	21
10 mi to disposal	57	40
Fixation additive rate (Calcilox, 5% of dry sludge)	-4	-10
Fixation additive rate (Calcilox, 10% of dry sludge)	5	13
Lime scrubbing process	-12	-8
Intermediate ponding and truck to landfill	-48	-1
200 MW, constrained pond acreage (50% of optimum)	-14	-34
200 MW, constrained pond acreage (75% of optimum)	-28	-38
Constrained pond acreage (50% of optimum)	56	36
Constrained pond acreage (75% of optimum)	29	128
1500 MW, constrained pond acreage (50% of optimum)	234	204
1500 MW, constrained pond acreage (75% of optimum)	168	158

TABLE 40. EFFECT OF CASE VARIATIONS ON TOTAL CAPITAL INVESTMENT AND ANNUAL REVENUE REQUIREMENTS - IUCS PROCESS

Variation from base case	Percent change from base case Capital investment	 Annual revenue requirement
200 MW new	-33	-33
200 MW existing, 25-yr remaining life	-31	-30
200 MW existing, 20-yr remaining life	-31	-30
200 MW existing, 15-yr remaining life	-32	-28
Existing, 25-yr remaining life	-1	2
Existing, 20-yr remaining life	-3	3
Existing, 15-yr remaining life	-4	5
1500 MW new	88	97
1500 MW existing, 25-yr remaining life	86	101
1500 MW existing, 20-yr remaining life	81	102
1500 MW existing, 15-yr remaining life	77	106
12% ash in coal	-13	-14
20% ash in coal	12	13
2% S in coal	-16	-12
5% S in coal	15	17
200 MW, no flyash	-32	-34
No flyash	-8	-12
1500 MW, no flyash	69	54
5 mi to disposal	6	23
10 mi to disposal	11	41
Fixation additive rate (lime, 3% of dry sludge)	-4	-6
Fixation additive rate (lime, 5% of dry sludge)	0	5
Lime scrubbing process	-3	-4

TABLE 41. EFFECT OF CASE VARIATIONS ON TOTAL CAPITAL INVESTMENT AND ANNUAL REVENUE REQUIREMENTS - CHEMFIX PROCESS

Variation from base case	Percent change from base case	
	Capital investment	Annual revenue requirement
200 MW	-32	-35
200 MW existing, 25-yr remaining life	-30	-33
200 MW existing, 20-yr remaining life	-31	-32
200 MW existing, 15-yr remaining life	-31	-31
Existing, 25-yr remaining life	-1	2
Existing, 20-yr remaining life	-2	3
Existing, 15-yr remaining life	-3	5
1500 MW new	78	106
1500 MW existing, 25-yr remaining life	77	111
1500 MW existing, 20-yr remaining life	72	112
1500 MW existing, 15-yr remaining life	69	115
12% ash in coal	-12	-11
20% ash in coal	5	9
2% S in coal	-18	-15
5% S in coal	10	18
200 MW, no flyash	-43	-46
No flyash	-25	-26
1500 MW, no flyash	35	40
5 mi to disposal	49	24
10 mi to disposal	99	43
Fixation additive rate (Portland cement, 22% of dry sludge)	20	95
Fixation additive rate (Portland cement, 12% of dry sludge)	9	45
Lime scrubbing process	-8	-11
Transport by truck to disposal area	13	-4

the 5- and 10-mi cases as compared to the unthickened slurry. These estimates are 58% (5 mi) and 97% (10 mi) greater than the base case. The 1-mi case is more expensive (13%) for pumping the 35% solids slurry than the base case (15% solids slurry). Truck transport of dewatered sludge (60% solids) to a landfill for disposal is more expensive than the base case for the 1-mi distance. The 5- and 10-mi truck-transport case variations are less expensive than the equivalent cases for pipeline transport (see Table 38). Annual revenue requirements for a 500-MW system increase with increasing constraints on pond acreage, decreasing settled density of pond solids, and increasing cost of synthetic pond lining.

Dravo Process

Capital Investment--

Capital investments are affected by the size of disposal pond required as with the untreated pond cases and therefore case variations with a smaller pond (quantity of sludge for disposal) require less capital investment. The Dravo process variation for intermediate ponding, truck transport, and landfill disposal of treated sludge requires 47% less capital investment than the base case (pond disposal).

Revenue Requirements--

Remaining plant life affects revenue requirements very little. The distance to the disposal pond significantly increases the revenue requirements. The case for a 5-mi distance is 21% more than the base case and the 10-mi distance increases the costs by 40%. The case variations for changing the amount of fixation additive result in a 10% decrease in revenue requirements below the base case requirements for one variation and a 13% increase for the other variation.

The revenue requirements for the Dravo system for intermediate ponding, truck transport, and landfill disposal are about the same (99%) as the base case.

IUCS Process

Capital Investment--

The remaining life of the power plant has no significant effect on capital investment. The quantity of sludge for disposal significantly affects capital requirements and an economy of scale exists.

The IUCS process requires flyash for fixation and therefore capital investments are increased for systems treating sludge that contains no flyash. Additional facilities are required to add flyash at the fixation facilities.

In all cases the sludge is transported by truck to the landfill disposal site and the capital investments are only slightly increased when the distance to the disposal site is increased to 5 and 10 mi (see Table 40).

Changes in the amount of fixation additive have no significant effect on the capital investments.

Annual Revenue Requirements--

The distance to the disposal site increases the annual revenue requirements by 23% for the 5-mi case and by 41% for the 10-mi case.

Annual revenue requirements are very slightly changed for case variations considering the changes in additive rates and the remaining life of the plant.

Chemfix Process

Capital Investment--

The remaining life of the power plant has no significant effect on the capital investment for the sludge disposal process. As with other alternatives, the quantity of sludge affects the capital investment, but not as significantly as the alternatives requiring a disposal pond. The distance to the disposal site causes the capital investment required for a new 500-MW plant to increase 49% when increased from 1 to 5 mi and 99% when increased to 10 mi.

Increased amounts of fixation additives also significantly increase the capital investment required. When the amount of increase in additive above the base case quantity results in a change in final sludge properties and curing time equivalent to similar changes for other alternatives, the capital investment is increased 20% above the base case capital investment. The Chemfix case variation for truck transport of treated sludge from a new 500-MW plant to the disposal area (base case requires pipeline transport) is less expensive (13%) than the base case.

Annual Revenue Requirements--

Plant remaining life affects annual revenue requirements very little. Annual revenue requirements for case variations considering the increased distances to the disposal site are increased by 24% for the 5-mi case and 43% for the 10-mi case.

The cost of increasing the amount of stabilization additive to change final sludge properties and the rate of stabilization such that the change is equivalent to that considered for other processes results in a 95% increase in annual revenue requirements.

The annual revenue requirements for the case variation of truck transport of treated sludge to the disposal site are 4% less than the requirements for the base case.

RECOMMENDATIONS

The evaluation of the four disposal alternatives considered in this study represents only a portion of the complete economic evaluation of FGD sludge disposal options. The state of technology for sludge treatment is changing continuously and new options are available now that were not available when this study was started. As a basic premise for this study, the four alternatives evaluated were considered to be environmentally and economically feasible. Current or potential environmental regulations, as well as more recent technology in FGD processes and disposal methods, may preclude the use of some alternatives from either an environmental or economic viewpoint.

Additional studies are therefore recommended to evaluate current alternatives whose applications may pend further economic analysis and to reevaluate the economics of the disposal alternatives in the current study which have had significant changes in process technology. Examples of these options are disposal of gypsum in a landfill and the physical stabilization of FGD sludge by blending or layering with flyash.

REFERENCES

1. Crowe, J. L., and H. W. Elder. Status and Plans for Waste Disposal From Utility Applications of Flue Gas Desulfurization Systems. In: Proceedings of the Symposium on Flue Gas Desulfurization, New Orleans, Louisiana, March 1976. EPA-600/2-76-136b (NTIS PB 262 722), May 1976. Vol II, pp. 565-577.

2. Leo, P. P., and J. Rossoff. Control of Waste and Water Pollution From Power Plant Flue Gas Cleaning Systems: First Annual R and D Report. EPA-600/7-76-018 (NTIS PB 259 211), October 1976.

3. Freas, R. C. The Stabilization and Disposal of Scrubber Sludges - The Dravo Process. Paper presented at The American Petroleum Institute Committee on Refinery Environmental Control, Salt Lake City, Utah, September 1975.

4. Lord, W. H. FGD Sludge Fixation and Disposal. Dravo Corporation, Pittsburgh, Pennsylvania, October 10, 1974.

5. Taub, Steven I. Treatment of Concentrated Waste Water to Produce Landfill Material. Paper presented at 5th International Pollution Engineering Exposition and Congress, Anaheim, California, November 10, 1976.

6. Kleiman, Gerald. Poz-O-Tec, A Practical Approach to Handling Flue Gas Scrubber Sludge. In: Proceedings of the American Power Conference, Chicago, Illinois, April 21-23, 1975. Vol 37, pp. 816-824.

7. Mullen, Hugh, Louis Ruggiano, and Steven I. Taub. The Physical and Environmental Properties of Poz-O-Tec. Paper presented at Engineering Foundation Conference on Disposal of Flue Gas Desulfurization Solids at Hueston Woods State Park, Ohio, October 17-22, 1976.

8. IU Conversion Systems, Inc. Poz-O-Tec Process for Economical and Environmentally Acceptable Stabilization of Scrubber Sludge and Ash. Philadelphia, Pennsylvania.

9. Conner, Jesse R. Ultimate Disposal of Liquid Wastes by Chemical Fixation. In: Proceedings of the 29th Annual Purdue Industrial Waste Conference, Purdue University, West Lafayette, Indiana, May 7-9, 1974. Part II, pp. 906-922.

10. McGlamery, G. G., et al. Detailed Cost Estimates for Advanced Effluent Desulfurization Processes. EPA-600/2-75-006 (NTIS PB 242 541), January 1975.

11. Jones, J. W. Research and Development for Control of Waste and Water Pollution From Flue Gas Cleaning Systems. In: Proceedings of the Symposium on Flue Gas Desulfurization, New Orleans, Louisiana, March 1976. EPA-600/2-76-136b (NTIS PB 262 722), May 1976. Vol II, pp. 579-604.

12. Fling, R. B., et al. Disposal of Flue Gas Cleaning Wastes: EPA Shawnee Field Evaluation--Initial Report. EPA-600/2-76-070 (NTIS PB 251 876), March 1976.

13. PEDCo-Environmental Specialists. Flue Gas Desulfurization Systems: Summary Report. November-December 1976.

14. Sanning, D. E. Development of a Data Base for the Future Regulation of Flue Gas Desulfurization Sludge Disposal. Paper presented at the ASME Winter Annual Meeting, Air Pollution Control Division, New York, December 1976.

15. Holland, W. F., et al. The Environmental Effects of Trace Elements in Pond Disposal of Ash and Flue Gas Desulfurization Sludge. EPRI 202 (NTIS PB 252 090), September 1975.

16. Rossoff, J., and R. C. Rossi. Disposal of Byproducts From Nonregenerable Flue Gas Desulfurization Systems: Initial Report. EPA-650/2-74-037a (NTIS PB 237 114), May 1974.

17. Princiotta, F. T. Sulfur Oxide Throwaway Sludge Evaluation Panel (SOTSEP), Vol II: Final Report - Technical Discussion. EPA-650/2-75-010b, (NTIS PB 242 619), April 1975.

18. Maloch, J. L. Chemical Fixation of FGD Sludges: Physical and Chemical Properties. In: Proceedings of the Symposium on Flue Gas Desulfurization, New Orleans, Louisiana, March 1976. EPA-600/2-76-136b (NTIS PB 262 722), May 1976. Vol II, pp. 627-645.

19. Rossoff, J., and R. C. Rossi. Flue Gas Cleaning Waste Disposal: EPA Shawnee Field Evaluation. In: Proceedings of the Symposium on Flue Gas Desulfurization, New Orleans, Louisiana, March 1976. EPA-600/2-76-136b (NTIS PB 262 722), May 1976. Vol II, pp. 605-626.

20. Selmeczi, J. G. Flue Gas Desulfurization and Stabilization. Dravo Lime Company, Pittsburgh, Pennsylvania, May 1975.

21. Selmeczi, J. G., et al. Stabilization of Sludge Slurries. U.S. Patent 3,920,795, November 1975.

22. Mullen, Hugh, and Steven I. Taub. Tracing Leachate From Landfills - A Conceptual Approach. Paper presented at National Conference on Disposal of Residue on Land, St. Louis, Missouri, September 14, 1976.

23. Duquesne Light News. Pittsburgh, Pennsylvania, October 1976.

24. Conner, Jesse R. Method of Making Wastes Nonpolluting and Disposable. U.S. Patent 3,837,872, September 1974.

25. Chemfix Data Package 1. Chemfix, Pittsburgh, Pennsylvania.

26. Federal Power Commission. Hydroelectric Power Evaluation, FPC P-35 (1968) and Supplement No. 1, FPC P-38 (1969). Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

27. U.S. Environmental Protection Agency. Standards of Performance for New Stationary Sources. Fed. Regist., Vol 36, No. 247, Part II, December 23, 1971.

28. Peters, M. S., and K. D. Timmerhaus. Plant Design and Economics for Chemical Engineers. McGraw-Hill Book Company, New York, 1968.

29. Guthrie, K. M. Capital Cost Estimating. Chem. Eng., March 24, 1969. Vol 76, pp. 114-142.

30. Popper, Herbert. Modern Cost Engineering Technique. McGraw-Hill Book Company, New York, 1970.

31. Perry, John H. Chemical Engineers' Handbook, Fourth Edition, McGraw-Hill Book Company, New York, 1963.

32. Richardson Engineering Services, Inc. The Richardson Rapid System, Vol 1, 3, 4, Solano Beach, California, 1976.

33. Pennsylvania Power Company. Bruce Mansfield Fact Sheet, April 1976.

APPENDIX A

TOTAL CAPITAL INVESTMENT AND ANNUAL REVENUE REQUIREMENT TABLES - ALL PROCESSES AND CASE VARIATIONS

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TABLE A-1. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Base case)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	128	1.4	0.7
Piping and insulation	121	1.3	0.7
Transport lines	1,109	12.1	6.4
Foundation and structural	7	0.1	0.1
Excavation, site preparation, roads and railroads	73	0.8	0.4
Electrical	395	4.3	2.3
Instrumentation	53	0.6	0.3
Buildings	0	-	-
Subtotal	1,886	20.6	10.9
Services and miscellaneous	28	0.3	0.2
Subtotal excluding pond	1,914	20.9	11.1
Pond construction	7,251	79.1	42.2
Subtotal direct investment	9,165	100.0	53.3
Engineering design and supervision	367	4.0	2.1
Architect and engineering contractor	49	0.5	0.3
Construction expense	1,102	12.1	6.4
Contractor fees	517	5.6	3.0
Subtotal	11,200	122.2	65.1
Contingency	2,240	24.4	13.0
Subtotal fixed investment	13,440	146.6	78.1
Allowance for startup and modifications	619	6.8	3.6
Interest during construction	1,613	17.6	9.3
Subtotal capital investment	15,672	171.0	91.0
Land	1,423	15.5	8.3
Working capital	116	1.3	0.7
Total capital investment	17,211	187.8	100.0

a. Basis
New 500-MW plant (30-yr life); 772 klb/hr (15% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis) 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 21.21 ft total depth, 407 acres.

TABLE A-2. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Base case)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	0.7
Maintenance				
Labor and materials				
4% of direct investment (plant)			76,600	2.3
3% of direct investment (pond)			217,500	6.6
Electricity	1,906 kkWh	0.029/kWh	55,300	1.7
Analyses	500 hr	17.00/man-hr	8,500	0.3
Subtotal conversion costs			576,900	17.6
Subtotal direct costs			576,900	17.6
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			940,300	28.7
Average cost of capital and taxes at 8.6% of total capital investment			1,480,100	45.1
Overhead				
Plant, 50% of conversion costs less utilities			260,800	7.9
Administrative, 10% of operating labor			21,900	0.7
Subtotal indirect costs			2,703,100	82.4
Total annual revenue requirements			2,280,000	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	8.08	4.04	0.94	

[a] Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $17,211,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-3. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: new 200-MW plant)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	78	1.5	0.8
Piping and insulation	96	1.9	1.0
Transport lines	746	14.8	7.5
Foundation and structural	6	0.1	0.1
Excavation, site preparation, roads and railroads	66	1.3	0.7
Electrical	354	7.0	3.6
Instrumentation	41	0.8	0.4
Buildings	-	-	-
Subtotal	1,387	27.4	14.1
Services and miscellaneous	21	0.4	0.2
Subtotal excluding pond	1,408	27.8	14.3
Pond construction	3,652	72.2	37.3
Subtotal direct investment	5,060	100.0	51.6
Engineering design and supervision	262	5.2	2.7
Architect and engineering contractor	38	0.8	0.4
Construction expense	713	14.0	7.3
Contractor fees	329	6.5	3.3
Subtotal	6,402	126.5	65.3
Contingency	1,280	25.3	13.1
Subtotal fixed investment	7,682	151.8	78.4
Allowance for startup and modifications	403	8.0	4.1
Interest during construction	922	18.2	9.4
Subtotal capital investment	9,007	178.0	91.9
Land	708	14.0	7.2
Working capital	85	1.7	0.9
Total capital investment	9,800	193.7	100.0

a. Basis
New 200-MW plant (30-yr life); 316 klb/hr (15% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 18.13 ft total depth, 202 acres.

TABLE A-4. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 200-MW plant)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	10.9
Maintenance				
Labor and materials				
4% of direct investment (plant)			56,300	2.8
3% of direct investment (pond)			109,600	5.4
Electricity	601 kkWh	0.031/kWh	18,600	0.9
Analyses	500 hr	17.00/hr	8,500	0.4
Subtotal conversion costs			412,000	20.4
Subtotal direct costs			412,000	20.4
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			540,800	26.9
Average cost of capital and taxes at 8.6% of total capital investment			842,800	41.8
Overhead				
Plant, 50% of conversion costs less utilities			196,700	9.8
Administrative, 10% of operating labor			21,900	1.1
Subtotal indirect costs			1,602,200	79.6
Total annual revenue requirements			2,014,200	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	12.12	6.06	1.44

a. Basis
Remaining plant life, 30 yr.
Coal burned, 175,238 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $9,800,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-5. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 200-MW plant, 25-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	81	1.9	0.9
Piping and insulation	96	2.2	1.1
Transport lines	746	17.3	8.8
Foundation and structural	6	0.1	0.1
Excavation, site preparation, roads and railroads	66	1.5	0.8
Electrical	354	8.2	4.2
Instrumentation	41	0.9	0.5
Buildings	-	-	-
Subtotal	1,390	32.1	16.4
Services and miscellaneous	21	.5	0.2
Subtotal excluding pond	1,411	32.6	16.6
Pond construction	2,923	67.4	34.5
Subtotal direct investment	4,334	100.0	51.1
Engineering design and supervision	237	5.5	2.8
Architect and engineering contractor	36	0.8	0.4
Construction expense	649	14.9	7.6
Contractor fees	293	6.8	3.5
Subtotal	5,549	128.0	65.4
Contingency	1,110	25.6	13.1
Subtotal fixed investment	6,659	153.6	78.5
Allowance for startup and modifications	374	8.6	4.4
Interest during construction	799	18.5	9.4
Subtotal capital investment	7,832	180.7	92.3
Land	566	13.1	6.7
Working capital	82	1.9	1.0
Total capital investment	8,480	195.7	100.0

a. Basis

Existing 200-MW plant (25-yr remaining life); 326 klb/hr (15% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 17.20 ft total depth, 162 acres.

TABLE A-6. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 200-MW plant, 25-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	11.9
Maintenance				
Labor and materials				
4% of direct investment (plant)			56,400	3.0
3% of direct investment (pond)			87,700	4.8
Electricity	992 kkWh	0.031/kWh	30,800	1.7
Analyses	500 hr	17.00/hr	8,500	0.5
Subtotal conversion costs			402,400	21.9
Subtotal direct costs			402,400	21.9
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6.4% of total capital investment less land and working capital			501,200	27.2
Average cost of capital and taxes at 8.6% of total capital investment			729,300	39.6
Overhead				
Plant, 50% of conversion costs less utilities			185,800	10.1
Administrative, 10% of operating labor			21,900	1.2
Subtotal indirect costs			1,438,200	78.1
Total annual revenue requirements			1,840,600	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	10.62	5.31	1.32	

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[a] Basis
Remaining plant life, 25 yr.
Coal burned, 180,952 lb/hr, 9,500 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $8,480,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-7. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 200-MW plant, 20-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	81	2.3	1.2
Piping and insulation	96	2.8	1.4
Transport lines	746	21.6	10.8
Foundation and structural	6	0.2	0.1
Excavation, site preparation, roads and railroads	66	1.9	1.0
Electrical	354	10.3	5.2
Instrumentation	41	1.2	0.6
Buildings	-	-	-
Subtotal	1,390	40.3	20.3
Services and miscellaneous	21	0.7	0.3
Subtotal excluding pond	1,411	41.0	20.6
Pond construction	2,034	59.0	29.7
Subtotal direct investment	3,445	100.0	50.3
Engineering design and supervision	203	5.9	3.0
Architect and engineering contractor	32	0.9	0.5
Construction expense	567	16.5	8.3
Contractor fees	246	7.1	3.6
Subtotal	4,493	130.4	65.7
Contingency	899	26.1	13.1
Subtotal fixed investment	5,392	156.5	78.8
Allowance for startup and modifications	336	9.8	4.9
Interest during construction	647	18.8	9.5
Subtotal capital investment	6,375	185.1	93.2
Land	392	11.4	5.7
Working capital	77	2.2	1.1
Total capital investment	6,844	198.7	100.0

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a. Basis

Existing 200-MW plant (20-yr remaining life); 326 klb/hr (15% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979.

Coal analysis (by wt): 3.5% S (dry basis), 16% ash.

Flyash removed with SO_2.

SO_2 and flyash removed to meet NSPS.

Limestone process with 1.5 stoichiometry based on SO_2 removed.

Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 15.88 ft total depth, 112 acres.

TABLE A-8. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 200-MW plant, 20-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	13.7
Maintenance				
Labor and materials				
4% of direct investment (plant)			56,400	3.5
3% of direct investment (pond)			61,000	3.8
Electricity	992 kkWh	0.031/kWh	30,800	1.9
Analyses	500 hr	17.00/hr	8,500	0.5
Subtotal conversion costs			375,700	23.4
Subtotal direct costs			375,700	23.4
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.0% of total capital investment less land and working capital			446,300	27.8
Average cost of capital and taxes at 8.6% of total capital investment			588,600	36.7
Overhead				
Plant, 50% of conversion costs less utilities			172,400	10.7
Administrative, 10% of operating labor			21,900	1.4
Subtotal indirect costs			1,229,200	76.6
Total annual revenue requirements			1,604,900	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	9.26	4.63	1.15

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a. Basis
Remaining plant life, 20 yr.
Coal burned, 180,952 lb/hr, 9,500 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment $6,844,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-9. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 200-MW plant, 15-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	81	3.0	1.5
Piping and insulation	96	3.5	1.7
Transport lines	746	27.3	13.6
Foundation and structural	6	0.2	0.1
Excavation, site preparation, roads and railroads	66	2.4	1.2
Electrical	354	13.0	6.4
Instrumentation	41	1.5	0.7
Buildings	-	-	-
Subtotal	1,390	50.9	25.2
Services and miscellaneous	21	0.8	0.4
Subtotal excluding pond	1,411	51.7	25.6
Pond construction	1,319	48.3	23.9
Subtotal direct investment	2,730	100.0	49.5
Engineering design and supervision	172	6.3	3.1
Architect and engineering contractor	29	1.1	0.5
Construction expense	496	18.2	9.1
Contractor fees	206	7.5	3.7
Subtotal	3,633	133.1	65.9
Contingency	727	26.6	13.2
Subtotal fixed investment	4,360	159.7	79.1
Allowance for startup and modifications	304	11.1	5.5
Interest during construction	523	19.2	9.5
Subtotal capital investment	5,187	190.0	94.1
Land	252	9.3	4.6
Working capital	72	2.6	1.3
Total capital investment	5,511	201.9	100.0

[a] Basis

Existing 200-MW plant (15-yr remaining life); 326 klb/hr (15% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 14.48 ft total depth, 72 acres.

TABLE A-10. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 200-MW plant, 15-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	15.3
Maintenance				
Labor and materials				
4% of direct investment (plant)			56,400	3.9
3% of direct investment (pond)			39,600	2.8
Electricity	992 kkWh	0.031/kWh	30,800	2.1
Analyses	500 hr	17.00/hr	8,500	0.6
Subtotal conversion costs			354,300	24.7
Subtotal direct costs			354,300	24.7
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 8.7% of total capital investment less land and working capital			421,300	29.4
Average cost of capital and taxes at 8.6% of total capital investment			473,900	33.1
Overhead				
Plant, 50% of conversion costs less utilities			161,700	11.3
Administrative, 10% of operating labor			21,900	1.5
Subtotal indirect costs			1,078,800	75.3
Total annual revenue requirements			1,433,100	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	8.27	4.14	1.02

a. Basis
Remaining plant life, 15 yr.
Coal burned, 180,952 lb/hr, 9,500 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $5,511,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-11. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 500-MW plant, 25-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	128	1.7	0.9
Piping and insulation	121	1.6	0.8
Transport lines	1,109	14.4	7.5
Foundation and structural	7	0.1	0.1
Excavation, site preparation, roads and railroads	73	0.9	0.5
Electrical	417	5.4	2.9
Instrumentation	53	0.7	0.4
Buildings	-	-	-
Subtotal	1,908	24.8	13.1
Services and miscellaneous	29	0.4	0.2
Subtotal excluding pond	1,937	25.2	13.3
Pond construction	5,759	74.8	39.5
Subtotal direct investment	7,696	100.0	52.8
Engineering design and supervision	326	4.2	2.2
Architect and engineering contractor	45	0.6	0.3
Construction expense	989	12.9	6.8
Contractor fees	453	2.9	3.1
Subtotal	9,509	123.6	65.2
Contingency	1,902	24.7	13.1
Subtotal fixed investment	11,411	148.3	78.3
Allowance for startup and modifications	565	7.3	3.9
Interest during construction	1,369	17.8	9.4
Subtotal capital investment	13,345	173.4	91.6
Land	1,126	14.6	7.7
Working capital	107	1.4	0.7
Total capital investment	14,578	189.4	100.0

a. Basis

Existing 500-MW plant (25-yr remaining life); 789 klb/hr (15% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 20.09 ft total depth, 372 acres.

TABLE A-12. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 500-MW plant, 25-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	7.5
Maintenance				
Labor and materials				
4% of direct investment (plant)			77,500	2.7
3% of direct investment (pond)			172,800	6.0
Electricity	2,037 kkWh	0.029/kWh	59,100	2.0
Analyses	500 hr	17.00/hr	8,500	0.3
Subtotal conversion costs			536,900	18.5
Subtotal direct costs			536,900	18.5
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6.4% of total capital investment less land and working capital			854,100	29.4
Average cost of capital and taxes at 8.6% of total capital investment			1,253,700	43.2
Overhead				
Plant, 50% of conversion costs less utilities			238,900	8.2
Administrative, 10% of operating labor			21,900	0.7
Subtotal indirect costs			2,368,600	81.5
Total annual revenue requirements			2,905,500	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	7.01	3.51	0.83	

a. Basis
- Remaining plant life, 25 yr.
- Coal burned, 438,095 lb/hr, 9,200 Btu/kWh.
- Power plant on-stream time, 7,000 hr/yr.
- Total capital investment $14,578,000.
- Midwest plant location, mid-1980 operating costs.

TABLE A-13. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 500-MW plant, 20-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	128	2.2	1.1
Piping and insulation	121	2.0	1.1
Transport lines	1,109	18.7	9.7
Foundation and structural	7	0.1	0.1
Excavation, site preparation, roads and railroads	73	1.2	0.6
Electrical	417	7.0	3.6
Instrumentation	53	0.9	0.5
Buildings	-	-	-
Subtotal	1,908	32.1	16.7
Services and miscellaneous	29	0.5	0.3
Subtotal excluding pond	1,937	32.6	17.0
Pond construction	3,998	67.4	35.1
Subtotal direct investment	5,935	100.0	52.1
Engineering design and supervision	273	4.6	2.4
Architect and engineering contractor	39	0.7	0.3
Construction expense	843	14.1	7.4
Contractor fees	372	6.3	3.3
Subtotal	7,462	125.7	65.5
Contingency	1,492	25.2	13.1
Subtotal fixed investment	8,954	150.9	78.6
Allowance for startup and modifications	496	8.4	4.3
Interest during construction	1,074	18.0	9.4
Subtotal capital investment	10,524	177.3	92.3
Land	778	13.2	6.8
Working capital	97	1.6	0.9
Total capital investment	11,399	192.1	100.0

a. Basis
Existing 500-MW plant (20-yr remaining life); 789 klb/hr (15% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 18.45 ft total depth, 222 acres.

TABLE A-14. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 500-MW plant, 20-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	9.0
Maintenance				
Labor and materials				
4% of direct investment (plant)			77,500	3.2
3% of direct investment (pond)			119,900	4.9
Electricity	2,037 kkWh	0.029/kWh	59,100	2.4
Analyses	500 hr	17.00/hr	8,500	0.4
Subtotal conversion costs			484,000	19.9
Subtotal direct costs			484,000	19.9
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7% of total capital investment less land and working capital			736,700	30.2
Average cost of capital and taxes at 8.6% of total capital investment			980,300	40.3
Overhead				
Plant, 50% of conversion costs less utilities			212,400	8.7
Administrative, 10% of operating labor			21,900	0.9
Subtotal indirect costs			1,951,300	80.1
Total annual revenue requirements			2,435,300	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	5.87	2.94	0.70	

a. Basis
Remaining plant life, 20 yr.
Coal burned, 438,095 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $11,399,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-15. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 500-MW plant, 15-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	128	2.8	1.4
Piping and insulation	121	2.7	1.4
Transport lines	1,109	24.5	12.6
Foundation and structural	7	0.2	0.1
Excavation, site preparation, roads and railroads	73	1.6	0.8
Electrical	417	9.2	4.7
Instrumentation	53	1.2	0.6
Buildings	-	-	-
Subtotal	1,908	42.2	21.6
Services and miscellaneous	29	0.6	0.3
Subtotal excluding pond	1,937	42.8	21.9
Pond construction	2,584	57.2	29.4
Subtotal direct investment	4,521	100.0	51.3
Engineering design and supervision	224	5.0	2.5
Architect and engineering contractor	35	0.8	0.4
Construction expense	719	15.8	8.2
Contractor fees	302	6.7	3.4
Subtotal	5,801	128.3	65.8
Contingency	1,160	25.7	13.1
Subtotal fixed investment	6,961	154.0	78.9
Allowance for startup and modifications	438	9.7	5.0
Interest during construction	835	18.4	9.4
Subtotal capital investment	8,234	182.1	93.3
Land	500	11.1	5.7
Working capital	88	1.9	1.0
Total capital investment	8,822	195.1	100.0

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[a] Basis

Existing 500-MW plant (15-yr remaining life); 789 klb/hr (15% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979.

Coal analysis (by wt): 3.5% S (dry basis), 16% ash.

Flyash removed with SO_2.

SO_2 and flyash removed to meet NSPS.

Limestone process with 1.5 stoichiometry based on SO_2 removed.

Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 16.71 ft, 143 acres.

TABLE A-16. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 500-MW plant, 15-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	10.3
Maintenance				
Labor and materials				
4% of direct investment (plant)			76,300	3.6
3% of direct investment (pond)			77,500	3.6
Electricity	2,037 kkWh	0.029/kWh	59,100	2.8
Analyses	500 hr	17.00/hr	8,500	0.4
Subtotal conversion costs			440,400	20.7
Subtotal direct costs			440,400	20.7
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 8.7% of total capital investment less land and working capital			716,400	33.7
Average cost of capital and taxes at 8.6% of total capital investment			758,700	35.6
Overhead				
Plant, 50% of conversion costs less utilities			191,200	9.0
Administrative, 10% of operating labor			21,900	1.0
Subtotal indirect costs			1,688,200	79.3
Total annual revenue requirements			2,128,600	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	5.13	2.57	0.61	

a. Basis
Remaining plant life, 15 yr.
Coal burned, 438,095 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $8,822,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-17. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: new 1500-MW plant)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	237	1.2	0.6
Piping and insulation	207	1.0	0.6
Transport lines	1,922	9.5	5.3
Foundation and structural	14	0.1	0.1
Excavation, site preparation, roads and railroads	77	0.4	0.2
Electrical	522	2.6	1.4
Instrumentation	53	0.3	0.1
Buildings	-	-	-
Subtotal	3,032	15.1	8.3
Services and miscellaneous	45	0.3	0.1
Subtotal excluding pond	3,077	15.4	8.4
Pond construction	16,946	84.6	46.5
Subtotal direct investment	20,023	100.0	54.9
Engineering design and supervision	587	2.9	1.6
Architect and engineering contractor	71	0.4	0.2
Construction expense	1,997	9.9	5.5
Contractor fees	936	4.7	2.6
Subtotal	23,614	117.9	64.8
Contingency	4,723	23.6	12.9
Subtotal fixed investment	28,337	141.5	77.7
Allowance for startup and modifications	1,139	5.7	3.1
Interest during construction	3,400	17.0	9.4
Subtotal capital investment	32,876	164.2	90.2
Land	3,359	16.8	9.2
Working capital	220	1.1	0.6
Total capital investment	36,455	182.1	100.0

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[a] Basis
New 1500-MW plant (30-yr life); 2,368 klb/hr (15% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 24.52 ft total depth, 761 acres.

TABLE A-18. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 1500-MW plant)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	26,280 man-hr	12.50/man-hr	328,500	4.9
Maintenance				
Labor and materials				
4% of direct investment (plant)			123,100	1.8
3% of direct investment (pond)			508,400	7.5
Electricity	5,170 kkWh	0.027/kWh	139,600	2.1
Analyses	1,000 hr	17.00/hr	17,000	0.3
Subtotal conversion costs			1,116,600	16.6
Subtotal direct costs			1,116,600	16.6
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,972,600	29.2
Average cost of capital and taxes at 8.6% of total capital investment			3,135,100	46.5
Overhead				
Plant, 50% of conversion costs less utilities			488,500	7.2
Administrative, 10% of operating labor			32,900	0.5
Subtotal indirect costs			5,629,100	83.4
Total annual revenue requirements			6,745,700	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	5.55	2.77	0.64	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 1,285,714 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $36,455,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-19. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 1500-MW plant, 25-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	241	1.5	0.8
Piping and insulation	207	1.2	0.7
Transport lines	1,922	11.6	6.3
Foundation and structural	12	0.1	0.1
Excavation, site preparation, roads and railroads	77	0.5	0.2
Electrical	474	2.9	1.6
Instrumentation	53	0.3	0.2
Buildings	-	-	-
Subtotal	2,986	18.1	9.9
Services and miscellaneous	45	0.3	0.1
Subtotal excluding pond	3,031	18.4	10.0
Pond construction	13,433	81.6	44.5
Subtotal direct investment	16,464	100.0	54.5
Engineering design and supervision	514	3.1	1.7
Architect and engineering contractor	63	0.4	0.2
Construction expense	1,750	10.6	5.8
Contractor fees	807	4.9	2.7
Subtotal	19,598	119.0	64.9
Contingency	3,920	23.8	12.9
Subtotal fixed investment	23,518	142.8	77.8
Allowance for startup and modifications	1,009	6.1	3.3
Interest during construction	2,822	17.2	9.4
Subtotal capital investment	27,349	166.1	90.5
Land	2,664	16.2	8.8
Working capital	199	1.2	0.7
Total capital investment	30,212	183.5	100.0

a. Basis

Existing 1500-MW plant (25-yr remaining life); 2,368 klb/hr (15% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979.

Coal analysis (by wt): 3.5% S (dry basis), 16% ash.

Flyash removed with SO_2.

SO_2 and flyash removed to meet NSPS.

Limestone process with 1.5 stoichiometry based on SO_2 removed.

Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 24.52 ft total depth, 761 acres.

TABLE A-20. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 1500-MW plant, 25-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	26,280 man-hr	12.50/man-hr	328,500	5.6
Maintenance				
Labor and materials				
4% of direct investment (plant)			121,200	2.1
3% of direct investment (pond)			403,000	6.9
Electricity	5,220 kkWh	0.027/kWh	140,900	2.4
Analyses	1,000 hr	17.00/hr	17,000	0.3
Subtotal conversion costs			1,010,600	17.3
Subtotal direct costs			1,010,600	17.3
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6.4% of total capital investment less land and working capital			1,750,300	30.0
Average cost of capital and taxes at 8.6% of total capital investment			2,598,200	44.6
Overhead				
Plant, 50% of conversion costs less utilities			434,800	7.5
Administrative, 10% of operating labor			32,900	0.6
Subtotal indirect costs			4,816,200	82.7
Total annual revenue requirements			5,826,800	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	4.69	2.35	0.55	

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a. Basis

Remaining plant life, 25 yr.
Coal burned, 1,314,286 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $30,212,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-21. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 1500-MW plant, 20-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	241	2.0	1.0
Piping and insulation	207	1.7	0.9
Transport lines	1,922	15.6	8.4
Foundation and structural	12	0.1	0.1
Excavation, site preparation, roads and railroads	77	0.6	0.3
Electrical	474	3.8	2.1
Instrumentation	53	0.4	0.2
Buildings	-	-	-
Subtotal	2,986	24.2	13.0
Services and miscellaneous	45	0.4	0.2
Subtotal excluding pond	3,031	24.6	13.2
Pond construction	9,312	75.4	40.7
Subtotal direct investment	12,343	100.0	53.9
Engineering design and supervision	420	3.4	1.8
Architect and engineering contractor	54	0.4	0.2
Construction expense	1,456	11.9	6.5
Contractor fees	648	5.2	2.8
Subtotal	14,921	120.9	65.2
Contingency	2,984	24.2	13.0
Subtotal fixed investment	17,905	145.1	78.2
Allowance for startup and modifications	859	7.0	3.7
Interest during construction	2,149	17.3	9.4
Subtotal capital investment	20,913	169.4	91.3
Land	1,817	14.8	7.9
Working capital	174	1.4	0.8
Total capital investment	22,904	185.6	100.0

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a. Basis
Existing 1500-MW plant (20-yr remaining life); 2,368 klb/hr (15% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 22.22 ft total depth, 519 acres.

TABLE A-22. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 1500-MW plant, 20-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	26,280 man-hr	12.50/man-hr	328,500	6.9
Maintenance				
Labor and materials				
4% of direct investment (plant)			121,200	2.6
3% of direct investment (pond)			279,300	5.9
Electricity	5,220 kkWh	0.027/kWh	140,900	3.0
Analyses	1,000 hr	17.00/hr	17,000	0.4
Subtotal conversion costs			886,900	18.8
Subtotal direct costs			886,900	18.8
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.0% of total capital investment less land and working capital			1,463,900	30.9
Average cost of capital and taxes at 8.6% of total capital investment			1,969,700	41.7
Overhead				
Plant, 50% of conversion costs less utilities			373,000	7.9
Administrative, 10% of operating labor			32,800	0.7
Subtotal indirect costs			3,839,400	81.2
Total annual revenue requirements			4,726,300	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	3.80	1.90	0.45	

a. Basis
- Remaining plant life, 20 yr.
- Coal burned, 1,314,286 lb/hr, 9,200 Btu/kWh.
- Power plant on-stream time, 7,000 hr/yr.
- Total capital investment, $22,904,000.
- Midwest plant location, mid-1980 operating costs.

TABLE A-23. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 1500-MW plant, 15-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	241	2.7	1.4
Piping and insulation	207	2.3	1.2
Transport lines	1,922	21.3	11.3
Foundation and structural	12	0.1	0.1
Excavation, site preparation, roads and railroads	77	0.9	0.5
Electrical	474	5.2	2.8
Instrumentation	53	0.6	0.3
Buildings	-	-	-
Subtotal	2,986	33.1	17.6
Services and miscellaneous	45	0.5	0.3
Subtotal excluding pond	3,031	33.6	17.9
Pond construction	5,992	66.4	35.2
Subtotal direct investment	9,023	100.0	53.1
Engineering design and supervision	333	3.7	2.0
Architect and engineering contractor	45	0.5	0.3
Construction expense	1,202	13.3	7.0
Contractor fees	511	5.7	3.0
Subtotal	11,114	123.2	65.4
Contingency	2,223	24.6	13.1
Subtotal fixed investment	13,337	147.8	78.5
Allowance for startup and modifications	735	8.1	4.3
Interest during construction	1,600	17.8	9.4
Subtotal capital investment	15,672	173.7	92.2
Land	1,173	13.0	6.9
Working capital	154	1.7	0.9
Total capital investment	16,999	188.4	100.0

a. Basis

Existing 1500-MW plant (15-yr remaining life); 2,368 klb/hr (15% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 20.26 ft total depth, 335 acres.

TABLE A-24. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 1500-MW plant, 15-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	26,280 man-hr	12.50/man-hr	328,500	8.3
Maintenance				
Labor and materials				
4% of direct investment (plant)			121,200	3.1
3% of direct investment (pond)			179,800	4.5
Electricity	5,220 kkWh	0.027/kWh	140,900	3.5
Analyses	1,000 hr	17.00/hr	17,000	0.4
Subtotal conversion costs			787,400	19.8
Subtotal direct costs			787,400	19.8
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 8.7% of total capital investment less land and working capital			1,363,500	34.4
Average cost of capital and taxes at 8.6% of total capital investment			1,461,900	36.8
Overhead				
Plant, 50% of conversion costs less utilities			323,200	8.2
Administrative, 10% of operating labor			32,900	0.8
Subtotal indirect costs			3,181,500	80.2
Total annual revenue requirements			3,968,900	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	3.19	1.60	0.38	

a. Basis
Remaining plant life, 15 yr.
Coal burned, 1,314,286 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $16,999,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-25. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: ash in coal 12% by wt)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	111	1.4	0.7
Piping and insulation	102	1.3	0.7
Transport lines	986	12.3	6.6
Foundation and structural	7	0.1	0.1
Excavation, site preparation, roads and railroads	69	0.9	0.5
Electrical	381	4.8	2.5
Instrumentation	53	0.7	0.3
Buildings	-	-	-
Subtotal	1,709	21.5	11.4
Services and miscellaneous	26	0.3	0.1
Subtotal excluding pond	1,735	21.8	11.5
Pond construction	6,218	78.2	41.4
Subtotal direct investment	7,953	100.0	52.9
Engineering design and supervision	339	4.3	2.3
Architect and engineering contractor	46	0.6	0.3
Construction expense	987	12.4	6.5
Contractor fees	464	5.8	3.1
Subtotal	9,789	123.1	65.1
Contingency	1,958	24.6	13.1
Subtotal fixed investment	11,747	147.7	78.2
Allowance for startup and modifications	553	7.0	3.7
Interest during construction	1,410	17.7	9.3
Subtotal capital investment	13,710	172.4	91.2
Land	1,215	15.3	8.1
Working capital	106	1.3	0.7
Total capital investment	15,031	189.0	100.0

a. Basis
New 500-MW plant (30-yr life); 638 klb/hr (15% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 12% ash, 11,100 Btu/lb.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 21.21 ft total depth. 407 acres.

TABLE A-26. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 12% ash in coal)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	7.5
Maintenance				
Labor and materials				
4% of direct investment (plant)			69,400	2.4
3% of direct investment (pond)			186,500	6.4
Electricity	1,384 kkWh	0.029/kWh	40,100	1.4
Analyses	500 hr	17.00/hr	8,500	0.3
Subtotal conversion costs			523,500	18.0
Subtotal direct costs			523,500	18.0
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			822,600	28.3
Average cost of capital and taxes at 8.6% of total capital investment			1,292,700	44.6
Overhead				
Plant, 50% of conversion costs less utilities			241,700	8.3
Administrative, 10% of operating labor			21,900	0.8
Subtotal indirect costs			2,378,900	82.0
Total annual revenue requirements			2,902,400	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	8.68	4.34	0.83	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 405,405 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $15,031,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-27. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: ash in coal 20% by wt)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	133	1.3	0.7
Piping and insulation	142	1.4	0.7
Transport lines	1,109	10.9	5.8
Foundation and structural	8	0.1	0.1
Excavation, site preparation, roads and railroads	73	0.7	0.4
Electrical	422	4.1	2.2
Instrumentation	53	0.5	0.3
Buildings	-	-	-
Subtotal	1,940	19.0	10.2
Services and miscellaneous	29	0.3	0.1
Subtotal excluding pond	1,969	19.3	10.3
Pond construction	8,230	80.7	43.2
Subtotal direct investment	10,199	100.0	53.5
Engineering design and supervision	393	3.9	2.1
Architect and engineering contractor	51	0.5	0.3
Construction expense	1,186	11.6	6.2
Contractor fees	561	5.5	2.9
Subtotal	12,390	121.5	65.0
Contingency	2,478	24.3	13.0
Subtotal fixed investment	14,868	145.8	78.0
Allowance for startup and modifications	664	6.5	3.5
Interest during construction	1,784	17.5	9.4
Subtotal capital investment	17,316	169.8	90.9
Land	1,614	15.8	8.5
Working capital	125	1.2	0.6
Total capital investment	19,055	186.8	100.0

a. Basis

New 500-MW plant (30-yr life); 923 klb/hr (15% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 20% ash, 9,900 Btu/lb.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 21.21 ft total depth, 407 acres.

TABLE A-28. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 20% ash in coal)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	6.1
Maintenance				
Labor and materials				
4% of direct investment (plant)			78,800	2.2
3% of direct investment (pond)			246,900	6.8
Electricity	2,742 kkWh	0.029/kWh	79,500	2.2
Analyses	500 hr	17.00/hr	8,500	0.2
Subtotal conversion costs			632,700	17.5
Subtotal direct costs			632,700	17.5
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,039,000	28.8
Average cost of capital and taxes at 8.6% of total capital investment			1,638,700	45.4
Overhead				
Plant, 50% of conversion costs less utilities			276,600	7.7
Administrative, 10% of operating labor			21,900	0.6
Subtotal indirect costs			2,976,200	82.5
Total annual revenue requirements			3,608,900.	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	7.44	3.72	1.03	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 454,545 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $19,055,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-29. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: S in coal 2% by wt)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	98	1.4	0.7
Piping and insulation	117	1.7	0.9
Transport lines	903	12.8	6.7
Foundation and structural	6	0.1	0.1
Excavation, site preparation, roads and railroads	69	1.0	0.5
Electrical	381	5.4	2.9
Instrumentation	41	0.6	0.3
Buildings	-	-	-
Subtotal	1,615	23.0	12.1
Services and miscellaneous	24	0.3	0.2
Subtotal excluding pond	1,639	23.3	12.3
Pond construction	5,397	76.7	40.3
Subtotal direct investment	7,036	100.0	52.6
Engineering design and supervision	316	4.5	2.4
Architect and engineering contractor	44	0.6	0.3
Construction expense	904	12.9	6.7
Contractor fees	423	6.0	3.2
Subtotal	8,723	124.0	65.2
Contingency	1,745	24.8	13.0
Subtotal fixed investment	10,468	148.8	78.2
Allowance for startup and modifications	507	7.2	3.8
Interest during construction	1,256	17.8	9.4
Subtotal capital investment	12,231	173.8	91.4
Land	1,055	15.1	7.9
Working capital	101	1.4	0.7
Total capital investment	13,387	190.3	100.0

a. Basis

New 500-MW plant (30-yr life); 537 klb/hr (15% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 2% S (dry basis), 16% ash, 10,700 Btu/lb HV.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 21.21 ft total depth, 407 acres.

TABLE A-30. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 2% S in coal)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	8.3
Maintenance				
Labor and materials				
4% of direct investment (plant)			65,600	2.5
3% of direct investment (pond)			161,900	6.1
Electricity	1,697 kkWh	0.029/kWh	49,200	1.9
Analyses	500 hr	17.00/hr	8,500	0.3
Subtotal conversion costs			504,200	19.1
Subtotal direct costs			504,200	19.1
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			733,900	27.8
Average cost of capital and taxes at 8.6% of total capital investment			1,151,500	43.7
Overhead				
Plant, 50% of conversion costs less utilities			227,500	8.6
Administrative, 10% of operating labor			21,900	0.8
Subtotal indirect costs			2,134,800	80.9
Total annual revenue requirements			2,639,000	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	9.37	4.69	0.75	

a. Basis

Remaining plant life, 30 yr.
Coal burned, 420,561 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $13,390,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-31. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: S in coal 5% by wt)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	155	1.4	0.7
Piping and insulation	142	1.3	0.7
Transport lines	1,329	11.9	6.4
Foundation and structural	7	0.1	0.1
Excavation, site preparation, roads and railroads	73	0.7	0.3
Electrical	471	4.2	2.3
Instrumentation	53	0.5	0.3
Buildings	-	-	-
Subtotal	2,230	20.1	10.8
Services and miscellaneous	33	0.3	0.2
Subtotal excluding pond	2,263	20.4	11.0
Pond construction	8,827	69.6	42.7
Subtotal direct investment	11,090	100.0	53.7
Engineering design and supervision	408	3.7	2.0
Architect and engineering contractor	53	0.5	0.3
Construction expense	1,285	11.5	6.2
Contractor fees	598	5.4	2.9
Subtotal	13,434	121.1	65.1
Contingency	2,687	24.3	13.0
Subtotal fixed investment	16,121	145.4	78.1
Allowance for startup and modifications	729	6.6	3.5
Interest during construction	1,935	17.4	9.4
Subtotal capital investment	18,785	169.4	91.0
Land	1,740	15.7	8.4
Working capital	130	1.2	0.6
Total capital investment	20,655	186.3	100.0

[a] Basis
New 500-MW plant (30-yr life); 1004 klb/hr (15% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 5% S (dry basis), 16% ash, 10,400 Btu/lb HV.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 21.21 ft total depth, 407 acres.

TABLE A-32. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 5% S in coal)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	5.7
Maintenance				
Labor and materials				
4% of direct investment (plant)			94,500	2.4
3% of direct investment (pond)			264,800	6.9
Electricity	2,193 kkWh	0.029/kWh	63,600	1.6
Analyses	500 hr	17.00/hr	8,500	0.2
Subtotal conversion costs			650,400	16.8
Subtotal direct costs			650,400	16.8
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,127,100	29.1
Average cost of capital and taxes at 8.6% of total capital investment			1,776,300	45.9
Overhead				
Plant, 50% of conversion costs less utilities			293,400	7.6
Administrative, 10% of operating labor			21,900	0.6
Subtotal indirect costs			3,218,700	83.2
Total annual revenue requirements			4,869,100	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	7.35	3.68	1.10	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 432,692 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $20,655,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-33. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: no flyash, 200-MW plant)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	54	1.6	0.8
Piping and insulation	74	2.2	1.1
Transport lines	526	15.6	7.8
Foundation and structural	3	0.1	0.1
Excavation, site preparation, roads and railroads	66	1.9	1.0
Electrical	338	10.0	5.0
Instrumentation	38	1.1	0.6
Buildings	-	-	-
Subtotal	1,099	32.5	16.4
Services and miscellaneous	16	0.5	0.2
Subtotal excluding pond	1,115	33.0	16.6
Pond construction	2,263	67.0	33.7
Subtotal direct investment	3,378	100.0	50.3
Engineering design and supervision	212	6.3	3.2
Architect and engineering contractor	33	1.0	0.5
Construction expense	530	15.6	7.8
Contractor fees	242	7.2	3.6
Subtotal	4,395	130.1	65.4
Contingency	879	26.0	13.1
Subtotal fixed investment	5,274	156.1	78.5
Allowance for startup and modifications	301	8.9	4.5
Interest during construction	633	18.8	9.4
Subtotal capital investment	6,208	183.8	92.4
Land	435	12.8	6.5
Working capital	73	2.2	1.1
Total capital investment	6,716	198.8	100.0

a. Basis
New 200-MW plant (30-yr life); 167 klb/hr (15% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed independently of SO_2 and sludge contains no flyash.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removal.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 16.29 ft total depth, 124 acres.

TABLE A-34. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 200-MW plant, no flyash)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	14.7
Maintenance				
Labor and materials				
4% of direct investment (plant)			44,600	3.0
3% of direct investment (pond)			67,900	4.5
Electricity	392 kkWh	0.031/kWh	12,200	0.8
Analyses	500 hr	17.00/hr	8,500	0.6
Subtotal conversion costs			352,200	23.6
Subtotal direct costs			352,200	23.6
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			372,500	24.9
Average cost of capital and taxes at 8.6% of total capital investment			577,600	38.6
Overhead				
Plant, 50% of conversion costs less utilities			170,700	11.4
Administrative, 10% of operating labor			21,900	1.5
Subtotal indirect costs			1,142,700	76.4
Total annual revenue requirements			1,494,900	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	17.08	8.50	1.07	

[a] Basis
Remaining plant life, 30 yr.
Coal burned, 175,238 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $6,716,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-35. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: no flyash)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	88	1.5	0.8
Piping and insulation	96	1.6	0.8
Transport lines	746	12.6	6.4
Foundation and structural	5	0.1	0.1
Excavation, site preparation, roads and railroads	66	1.1	0.6
Electrical	364	6.1	3.2
Instrumentation	53	0.9	0.5
Buildings	-	-	-
Subtotal	1,418	23.9	12.4
Services and miscellaneous	21	0.3	0.2
Subtotal excluding pond	1,439	24.2	12.6
Pond construction	4,499	75.8	39.5
Subtotal direct investment	5,938	100.0	52.1
Engineering design and supervision	289	4.9	2.5
Architect and engineering contractor	41	0.7	0.4
Construction expense	791	13.2	6.9
Contractor fees	372	6.3	3.3
Subtotal	7,431	125.1	65.2
Contingency	1,486	25.1	13.0
Subtotal fixed investment	8,917	150.2	78.2
Allowance for startup and modifications	442	7.4	3.9
Interest during construction	1,070	18.0	9.4
Subtotal capital investment	10,429	175.6	91.5
Land	876	14.7	7.7
Working capital	92	1.6	0.8
Total capital investment	11,397	191.9	100.0

[a] Basis

New 500-MW plant (30-yr life); 409 klb/hr (15% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed independently of SO_2 and sludge contains no flyash.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 18.98 ft total depth, 250 acres.

TABLE A-36. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: separate system, no flyash)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	9.5
Maintenance				
Labor and materials				
4% of direct investment (plant)			57,600	2.5
3% of direct investment (pond)			135,000	5.9
Electricity	1,071 kkWh	0.029/kWh	31,100	1.4
Analyses	500 hr	17.00/hr	8,500	0.4
Subtotal conversion costs			451,200	19.7
Subtotal direct costs			451,200	19.7
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			625,700	27.3
Average cost of capital and taxes at 8.6% of total capital investment			980,100	42.8
Overhead				
Plant, 50% of conversion costs less utilities			210,000	9.2
Administrative, 10% of operating labor			21,900	1.0
Subtotal indirect costs			1,837,700	80.3
Total annual revenue requirements			2,288,900	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	10.63	5.32	0.65

a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $11,397,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-37. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: no flyash, 1500-MW plant)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	151	1.2	0.6
Piping and insulation	169	1.3	0.7
Transport lines	1,329	10.4	5.6
Foundation and structural	9	0.1	0.1
Excavation, site preparation, roads and railroads	73	0.6	0.3
Electrical	443	3.5	1.9
Instrumentation	53	0.4	0.2
Buildings	-	-	-
Subtotal	2,227	17.5	9.4
Services and miscellaneous	33	0.3	0.2
Subtotal excluding pond	2,260	17.8	9.6
Pond construction	10,468	82.2	44.3
Subtotal direct investment	12,728	100.0	53.9
Engineering design and supervision	447	3.5	1.9
Architect and engineering contractor	57	0.4	0.2
Construction expense	1,405	11.1	6.0
Contractor fees	664	5.2	2.8
Subtotal	15,301	120.2	64.8
Contingency	3,060	24.1	13.0
Subtotal fixed investment	18,361	144.3	77.8
Allowance for startup and modifications	789	6.2	3.3
Interest during construction	2,203	17.3	9.4
Subtotal capital investment	21,353	167.8	90.5
Land	2,076	16.3	8.8
Working capital	166	1.3	0.7
Total capital investment	23,595	185.4	100.0

a. Basis

New 1500-MW plant (30-yr life); 1,228 klb/hr (15% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed independently of SO_2 and sludge contains no flyash.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 23.12 ft total depth, 591 acres.

TABLE A-38. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 1500-MW plant, no flyash)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	26,280 man-hr	12.50/man-hr	328,500	7.2
Maintenance				
Labor and materials				
4% of direct investment (plant)			90,400	2.0
3% of direct investment (pond)			314,000	6.9
Electricity	2,872 kkWh	0.027/kWh	77,500	1.7
Analyses	1,000 hr	17.00/hr	17,000	0.4
Subtotal conversion costs			827,400	18.2
Subtotal direct costs			827,400	18.2
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,281,200	28.2
Average cost of capital and taxes at 8.6% of total capital investment			2,029,200	44.6
Overhead				
Plant, 50% of conversion costs less utilities			374,900	8.3
Administrative, 10% of operating labor			32,900	0.7
Subtotal indirect costs			3,718,200	81.8
Total annual revenue requirements			4,545,600	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	7.04	3.52	0.43	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 1,285,714 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment $23,595,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-39. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: pond disposal 5 mi from facilities)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	806	5.5	3.0
Piping and insulation	119	0.8	0.4
Transport lines	5,547	38.1	20.7
Foundation and structural	8	0.1	0.1
Excavation, site preparation, roads and railroads	249	1.7	0.9
Electrical	428	2.9	1.6
Instrumentation	53	0.4	0.2
Buildings	0	-	-
Subtotal	7,210	49.5	26.9
Services and miscellaneous	108	0.7	0.4
Subtotal excluding pond	7,318	50.2	27.3
Pond construction	7,251	49.8	27.0
Subtotal direct investment	14,569	100.0	54.3
Engineering design and supervision	367	2.5	1.4
Architect and engineering contractor	49	0.3	0.2
Construction expense	1,977	13.7	7.4
Contractor fees	735	5.0	2.7
Subtotal	17,697	121.5	66.0
Contingency	3,539	24.3	13.2
Subtotal fixed investment	21,236	145.8	79.2
Allowance for startup and modifications	1,399	9.6	5.2
Interest during construction	2,548	17.5	9.5
Subtotal capital investment	25,183	172.9	93.9
Land	1,423	9.7	5.3
Working capital	230	1.6	0.8
Total capital investment	26,836	184.2	100.0

a. Basis

New 500-MW plant (30-yr life); 772 klb/hr (15% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 5 mi from scrubber facilities, 50% solids settled density, 21.21 ft total depth, 407 acres.

TABLE A-40. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: disposal area 5 mi from scrubber facilities)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	35,040 man-hr	12.50/man-hr	438,000	7.9
Maintenance				
Labor and materials				
4% of direct investment (plant)			292,700	5.3
3% of direct investment (pond)			217,500	3.9
Electricity	7,911 kkWh	0.029/kWh	229,400	4.2
Analyses	500 hr	17.00/hr	8,500	0.2
Subtotal conversion costs			1,186,100	21.5
Subtotal direct costs			1,186,100	21.5
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,511,000	27.3
Average cost of capital and taxes at 8.6% of total capital investment			2,307,900	41.8
Overhead				
Plant, 50% of conversion costs less utilities			478,300	8.6
Administrative, 10% of operating labor			43,800	0.8
Subtotal indirect costs			4,341,000	78.5
Total annual revenue requirements			5,527,100	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	13.61	6.81	1.58	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $26,836,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-41. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: pond disposal 10 mi from facilities)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	850	4.1	2.3
Piping and insulation	119	0.6	0.3
Transport lines	11,094	53.5	29.7
Foundation and structural	9	0.1	0.1
Excavation, site preparation, roads and railroads	469	2.3	1.2
Electrical	636	3.1	1.7
Instrumentation	53	0.3	0.1
Buildings	0	-	-
Subtotal	13,230	64.0	35.4
Services and miscellaneous	198	0.9	0.5
Subtotal excluding pond	13,428	64.9	35.9
Pond construction	7,251	35.1	19.4
Subtotal direct investment	20,679	100.0	55.3
Engineering design and supervision	367	1.8	1.0
Architect and engineering contractor	49	0.2	0.1
Construction expense	2,832	13.7	7.5
Contractor fees	960	4.6	2.6
Subtotal	24,887	120.3	66.5
Contingency	4,977	24.1	13.3
Subtotal fixed investment	29,864	144.4	79.8
Allowance for startup and modifications	2,261	10.9	6.0
Interest during construction	3,584	17.4	9.6
Subtotal capital investment	35,709	172.7	95.4
Land	1,423	6.9	3.8
Working capital	288	1.4	0.8
Total capital investment	37,420	181.0	100.0

a. Basis
New 500-MW plant (30-yr life); 772 klb/hr (15% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 10 mi from scrubber facilities, 50% solids settled density, 21.21 ft total depth, 407 acres.

TABLE A-42. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: disposal area 10 mi from scrubber facilities)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	35,040 man-hr	12.50/man-hr	438,000	5.8
Maintenance				
Labor and materials				
4% of direct investment (plant)			537,100	7.2
3% of direct investment (pond)			217,500	2.9
Electricity	10,261 kkWh	0.029/kWh	297,600	4.0
Analyses	500 hr	17.00/hr	8,500	0.1
Subtotal conversion costs			1,498,700	20.0
Subtotal direct costs			1,498,700	20.0
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			2,142,500	28.5
Average cost of capital and taxes at 8.6% of total capital investment			3,218,100	42.9
Overhead				
Plant, 50% of conversion costs less utilities			600,500	8.0
Administrative, 10% of operating labor			43,800	0.6
Subtotal indirect costs			6,004,900	80.0
Total annual revenue requirements			7,503,600	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	18.48	9.24	2.14	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $37,420,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-43. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: lime process, 1.1 stoichiometry)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	156	1.8	1.0
Piping and insulation	147	1.7	0.9
Transport lines	1,329	15.3	8.1
Foundation and structural	8	0.1	0.1
Excavation, site preparation, roads and railroads	72	0.8	0.4
Electrical	443	5.1	2.7
Instrumentation	53	0.6	0.3
Buildings	-	-	-
Subtotal	2,208	25.4	13.5
Services and miscellaneous	33	0.4	0.2
Subtotal excluding pond	2,241	25.8	13.7
Pond construction	6,436	74.2	39.4
Subtotal direct investment	8,677	100.0	53.1
Engineering design and supervision	345	4.0	2.1
Architect and engineering contractor	47	0.5	0.3
Construction expense	1,098	12.7	6.7
Contractor fees	496	5.7	3.1
Subtotal	10,663	122.9	65.3
Contingency	2,133	24.6	13.0
Subtotal fixed investment	12,796	147.5	78.3
Allowance for startup and modifications	636	7.3	3.9
Interest during construction	1,536	17.7	9.4
Subtotal capital investment	14,968	172.5	91.6
Land	1,258	14.5	7.7
Working capital	113	1.3	0.7
Total capital investment	16,339	188.3	100.0

a. Basis:
New 500-MW plant (30-yr life); 1,008 klb/hr (10% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Lime process with 1.1 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 20.67 ft total depth, 359 acres.

TABLE A-44. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: lime process with 1.1 stoichiometry)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	7.0
Maintenance				
Labor and materials				
4% of direct investment (plant)			89,600	2.8
3% of direct investment (pond)			193,100	6.1
Electricity	1,906 kkWh	0.029/kWh	55,300	1.8
Analyses	500 hr	17.00/hr	8,500	0.3
Subtotal conversion costs			565,500	18.0
Subtotal direct costs			565,500	18.0
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			898,100	28.7
Average cost of capital and taxes at 8.6% of total capital investment			1,395,400	44.5
Overhead				
Plant, 50% of conversion costs less utilities			255,100	8.1
Administrative, 10% of operating labor			21,900	0.7
Subtotal indirect costs			2,570,500	82.0
Total annual revenue requirements			3,136,000	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	5.87	4.44	0.90

a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $16,226,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-45. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: clarify and pump 1 mi from facilities, 35% solids)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	1,051	10.7	5.6
Piping and insulation	187	1.9	1.0
Transport lines	697	7.1	3.8
Foundation and structural	7	0.1	0.1
Excavation, site preparation, roads and railroads	97	1.0	0.5
Electrical	422	4.3	2.3
Instrumentation	54	0.6	0.3
Buildings	-	-	-
Subtotal	2,515	25.7	13.6
Services and miscellaneous	38	0.3	0.2
Subtotal excluding pond	2,553	26.0	13.8
Pond construction	7,251	74.0	39.2
Subtotal direct investment	9,804	100.0	53.0
Engineering design and supervision	425	4.3	2.3
Architect and engineering contractor	63	0.6	0.4
Construction expense	1,217	12.5	6.6
Contractor fees	544	5.5	2.9
Subtotal	12,053	122.9	65.2
Contingency	2,411	24.6	13.0
Subtotal fixed investment	14,464	147.5	78.2
Allowance for startup and modifications	721	7.4	3.9
Interest during construction	1,736	17.7	9.4
Subtotal capital investment	16,921	172.6	91.5
Land	1,423	14.5	7.7
Working capital	146	1.5	0.8
Total capital investment	18,490	188.6	100.0

[a] Basis

New 500-MW plant (30-yr life); 331 klb/hr (35% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 35% solids settled density, 21.21 ft total depth, 407 acres.

TABLE A-46. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: clarify and pump - 1 mi from scrubber facilities)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	26,280 man-hr	12.50/man-hr	328,500	8.9
Maintenance				
Labor and materials				
4% of direct investment (plant)			102,100	2.7
3% of direct investment (pond)			217,500	5.9
Electricity	1,996 kkWh	0.029/kWh	57,900	1.6
Analyses	1,000 hr	17.00/hr	17,000	0.5
Subtotal conversion costs			723,000	19.6
Subtotal direct costs			723,000	19.6
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,015,300	27.5
Average cost of capital and taxes at 8.6% of total capital investment			1,590,100	43.0
Overhead				
Plant, 50% of conversion costs less utilities			332,500	9.0
Administrative, 10% of operating labor			32,900	0.9
Subtotal indirect costs			2,970,800	80.4
Total annual revenue requirements			3,693,800	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	9.10	4.55	1.06	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $18,490,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-47. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: clarify and pump 5 mi from facilities, 35% solids)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	1,736	13.0	7.0
Piping and insulation	177	1.3	0.7
Transport lines	3,484	26.0	13.9
Foundation and structural	7	0.1	0.1
Excavation, site preparation, roads and railroads	97	0.7	0.4
Electrical	491	3.7	2.0
Instrumentation	53	0.4	0.2
Buildings	-	-	-
Subtotal	6,045	45.2	24.3
Services and miscellaneous	91	0.6	0.4
Subtotal excluding pond	6,136	45.8	24.7
Pond construction	7,251	54.2	29.1
Subtotal direct investment	13,387	100.0	53.8
Engineering design and supervision	425	3.2	1.7
Architect and engineering contractor	63	0.5	0.3
Construction expense	1,800	13.3	7.2
Contractor fees	690	5.2	2.8
Subtotal	16,365	122.2	65.8
Contingency	3,273	24.5	13.1
Subtotal fixed investment	19,638	146.7	78.9
Allowance for startup and modifications	1,239	9.3	5.0
Interest during construction	2,357	17.6	9.5
Subtotal capital investment	23,234	173.6	93.4
Land	1,423	10.6	5.7
Working capital	224	1.7	0.9
Total capital investment	24,881	185.9	100.0

a. Basis
New 500-MW plant (30-yr life); 331 klb/hr (35% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 5 mi from scrubber facilities, 35% solids settled density, 21.21 ft total depth, 407 acres.

TABLE A-48. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: clarify and pump - 5 mi from scrubber facilities)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	35,040 man-hr	12.50/man-hr	438,000	8.4
Maintenance				
Labor and materials				
4% of direct investment (plant)			245,400	4.7
3% of direct investment (pond)			217,500	4.2
Electricity	285 kWh	0.029/kWh	240,300	4.6
Analyses	1,000 hr	17.00/hr	17,000	0.3
Subtotal conversion costs			1,158,200	22.3
Subtotal direct costs			1,158,200	22.3
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,394,000	26.9
Average cost of capital and taxes at 8.6% of total capital investment			2,139,800	41.2
Overhead				
Plant, 50% of conversion costs less utilities			458,900	8.8
Administrative, 10% of operating labor			43,800	0.8
Subtotal indirect costs			4,036,500	77.7
Total annual revenue requirements			5,194,700	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	12.79	6.40	1.48

a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $24,881,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-49. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: clarify and pump
10 mi from facilities, 35% solids)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	1,761	10.3	5.6
Piping and insulation	177	1.0	0.4
Transport lines	6,969	40.5	22.2
Foundation and structural	7	0.1	0.1
Excavation, site preparation, roads and railroads	97	0.6	0.3
Electrical	698	4.1	2.2
Instrumentation	53	0.3	0.2
Buildings	-	-	-
Subtotal	9,762	56.9	31.0
Services and miscellaneous	146	0.8	0.5
Subtotal excluding pond	9,908	57.7	31.5
Pond construction	7,251	42.3	23.0
Subtotal direct investment	17,159	100.0	54.5
Engineering design and supervision	425	2.5	1.4
Architect and engineering contractor	63	0.4	0.2
Construction expense	2,350	13.6	7.5
Contractor fees	833	4.9	2.6
Subtotal	20,830	121.4	66.2
Contingency	4,166	24.3	13.3
Subtotal fixed investment	24,996	145.7	79.5
Allowance for startup and modifications	1,775	10.3	5.6
Interest during construction	3,000	17.5	9.5
Subtotal capital investment	29,771	173.5	94.6
Land	1,423	8.3	4.6
Working capital	264	1.5	0.8
Total capital investment	31,458	183.3	100.0

[a] Basis
New 500-MW plant (30-yr life); 331 klb/hr (35% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 10 mi from scrubber facilities, 35% solids settled density, 21.21 ft total depth, 407 acres.

TABLE A-50. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: clarify and pump - 10 mi from scrubber facilities)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	35,040 man-hr	12.50/man-hr	438,000	6.8
Maintenance				
Labor and materials				
4% of direct investment (plant)			396,300	6.1
3% of direct investment (pond)			217,500	3.4
Electricity	10,746 kkWh	0.029/kWh	311,600	4.8
Analyses	1,000 hr	17.00/hr	17,000	0.3
Subtotal conversion costs			1,380,400	21.4
Subtotal direct costs			1,380,400	21.4
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,786,300	27.7
Average cost of capital and taxes at 8.6% of total capital investment			2,705,400	41.9
Overhead				
Plant, 50% of conversion costs less utilities			534,400	8.3
Administrative, 10% of operating labor			43,800	0.7
Subtotal indirect costs			5,069,900	78.6
Total annual revenue requirements			6,450,300	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	15.89	7.95	1.84	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $31,458,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-51. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: clarify, filter, and truck to landfill, 60% solids)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,094	58.6	25.3
Piping and insulation	172	4.8	2.1
Transport lines	-	-	-
Foundation and structural	85	2.4	1.0
Excavation, site preparation, roads and railroads	61	1.7	0.7
Electrical	427	11.9	5.1
Instrumentation	56	1.6	0.7
Buildings	97	2.7	1.2
Subtotal	2,992	83.7	36.1
Services and miscellaneous	45	1.3	0.5
Subtotal excluding trucks and equipment	3,037	85.0	36.6
Trucks and earthmoving equipment	538	15.0	6.5
Subtotal direct investment	3,575	100.0	43.1
Engineering design and supervision	276	7.7	3.3
Architect and engineering contractor	69	1.9	0.8
Construction expense	629	17.6	7.6
Contractor fees	253	7.1	3.1
Subtotal	4,802	134.3	57.9
Contingency	960	26.9	11.6
Subtotal fixed investment	5,762	161.2	69.5
Allowance for startup and modifications	522	14.6	6.3
Interest during construction	691	19.3	8.3
Subtotal capital investment	6,975	195.1	84.1
Land	976	27.3	11.8
Working capital	343	9.6	4.1
Total capital investment	8,294	232.0	100.0

[a] Basis
New 500-MW plant (30-yr life); 193 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Landfill disposal, 1 mi from scrubber facilities, 60% solids materials, land requirement - 188 acres at 30 ft deep.

TABLE A-52. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: clarify, filter, and truck - 1 mi from scrubber facilities)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision				
Plant	35,046 man-hr	12.50/man-hr	438,000	11.5
Solids disposal equipment	52,560 man-hr	17.00/man-hr	893,500	23.5
Maintenance--plant labor and material, 4% of direct investment			121,500	3.2
Landfill operation				
Land preparation			10,700	0.3
Trucks (fuel and maintenance)	410,125 tons	0.06/ton	24,600	0.6
Earthmoving equipment (fuel and maintenance)	410,125 tons	0.16/ton	65,600	1.7
Electricity	2,086 kkWh	0.029/kWh	60,500	1.6
Analyses	1,000 hr	17.00/hr	17,000	0.4
Subtotal conversion costs			1,631,400	42.8
Subtotal direct costs			1,631,400	42.8
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			546,100	14.4
Average cost of capital and taxes at 8.6% of total capital investment			713,300	18.7
Overhead				
Plant, 50% of conversion costs less utilities			785,400	20.6
Administrative, 10% of operating labor			133,200	3.5
Subtotal indirect costs			2,178,000	57.2
Total annual revenue requirements			3,809,400	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	9.38	4.69	1.09

a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $18,490,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-53. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: clarify, filter, and truck 5 mi to landfill, 60% solids)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,094	54.4	23.8
Piping and insulation	172	4.5	1.9
Transport lines	-	-	-
Foundation and structural	85	2.2	1.0
Excavation, site preparation, roads and railroads	61	1.6	0.7
Electrical	427	11.1	4.8
Instrumentation	56	1.5	0.6
Buildings	97	2.5	1.1
Subtotal	2,992	77.8	33.9
Services and miscellaneous	45	1.2	0.5
Subtotal excluding trucks and equipment	3,037	79.0	34.4
Trucks and earthmoving equipment	809	21.0	9.2
Subtotal direct investment	3,846	100.0	43.6
Engineering design and supervision	276	7.2	3.1
Architect and engineering contractor	69	1.8	0.8
Construction expense	629	16.4	7.1
Contractor fees	267	6.9	3.0
Subtotal	5,087	132.3	57.6
Contingency	1,017	26.4	11.6
Subtotal fixed investment	6,104	158.7	69.2
Allowance for startup and modifications	530	13.8	6.0
Interest during construction	732	19.0	8.3
Subtotal capital investment	7,366	191.5	83.5
Land	976	25.4	11.0
Working capital	483	12.6	5.5
Total capital investment	8,825	229.5	100.0

a. Basis
New 500-MW plant (30-yr life); 193 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Landfill disposal, 5 mi from scrubber facilities, 60% solids materials, land requirement - 188 acres at 30 ft deep.

TABLE A-54. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: clarify, filter, and truck - 5 mi from scrubber facilities)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	8.9
Solids disposal equipment	87,600 man-hr	17.00/man-hr	1,489,200	30.2
Maintenance--plant labor and material, 4% of direct investment			121,500	2.5
Landfill operation				
Land preparation			10,700	0.2
Trucks (fuel and maintenance)	410,125 tons	0.20/ton	82,000	1.7
Earthmoving equipment (fuel and maintenance)	410,125 tons	0.16/ton	65,600	1.3
Electricity	2,086 kkWh	0.029/kWh	60,500	1.2
Analyses	1,000 hr	17.00/hr	17,000	0.4
Subtotal conversion costs			2,284,500	46.4
Subtotal direct costs			2,284,500	46.4
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			576,800	11.7
Average cost of capital and taxes at 8.6% of total capital investment			759,000	15.4
Overhead				
Plant, 50% of conversion costs less utilities			1,112,000	22.6
Administrative, 10% of operating labor			192,700	3.9
Subtotal indirect costs			2,640,500	53.6
Total annual revenue requirements			4,925,000	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	12.13	6.07	1.41

a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $24,881,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-55. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: clarify, filter, and truck 10 mi to landfill, 60% solids)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,094	51.6	22.6
Piping and insulation	172	4.2	1.9
Transport lines	-	-	-
Foundation and structural	85	2.1	0.9
Excavation, site preparation, roads and railroads	61	1.5	0.7
Electrical	427	10.5	4.6
Instrumentation	56	1.4	0.6
Buildings	97	2.4	1.0
Subtotal	2,992	73.7	32.3
Services and miscellaneous	45	1.1	0.5
Subtotal excluding trucks and equipment	3,037	74.8	32.8
Trucks and earthmoving equipment	1,025	25.2	11.1
Subtotal direct investment	4,062	100.0	43.9
Engineering design and supervision	276	6.8	3.0
Architect and engineering contractor	69	1.7	0.8
Construction expense	629	15.4	6.8
Contractor fees	279	6.9	3.0
Subtotal	5,315	130.8	57.5
Contingency	1,063	26.2	11.5
Subtotal fixed investment	6,378	157.0	69.0
Allowance for startup and modifications	535	13.2	5.8
Interest during construction	765	18.8	8.2
Subtotal capital investment	7,678	189.0	83.0
Land	976	24.1	10.6
Working capital	595	14.6	6.4
Total capital investment	9,249	227.7	100.0

a. Basis
New 500-MW plant (30-yr life); 193 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Landfill disposal, 10 mi from scrubber facilities, land requirement - 188 acres at 30 ft deep.

TABLE A-56. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: clarify, filter, and truck - 10 mi from scrubber facilities)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	7.5
Solids disposal equipment	113,880 man-hr	17.00/man-hr	1,936,000	33.3
Maintenance--plant labor and material, 4% of direct investment			121,500	2.1
Landfill operation				
Land preparation			10,700	0.2
Trucks (fuel and maintenance)	410,125 tons	0.39/ton	160,000	2.8
Earthmoving equipment (fuel and maintenance)	410,125 tons	0.16/ton	65,600	1.1
Electricity	2,086 kkWh	0.029/kWh	60,500	1.0
Analyses	1,000 hr	17.00/hr	17,000	0.3
Subtotal conversion costs			2,809,300	48.3
Subtotal direct costs			2,809,300	48.3
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			601,200	10.3
Average cost of capital and taxes at 8.6% of total capital investment			795,500	13.7
Overhead				
Plant, 50% of conversion costs less utilities			1,374,400	23.6
Administrative, 10% of operating labor			237,400	4.1
Subtotal indirect costs			3,008,500	51.7
Total annual revenue requirements			5,817,800	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	14.40	7.20	1.66	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $31,458,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-57. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: constrained pond acreage, 200-MW plant)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	78	1.1	0.6
Piping and insulation	96	1.3	0.7
Transport lines	746	10.4	5.8
Foundation and structural	6	0.1	0.1
Excavation, site preparation, roads and railroads	66	0.9	0.5
Electrical	354	5.0	2.8
Instrumentation	41	0.6	0.3
Buildings	-	-	-
Subtotal	1,387	19.4	10.8
Services and miscellaneous	21	0.3	0.2
Subtotal excluding pond	1,408	19.7	11.0
Pond construction	5,726	80.3	44.8
Subtotal direct investment	7,134	100.0	55.8
Engineering design and supervision	326	4.6	2.6
Architect and engineering contractor	45	0.6	0.4
Construction expense	885	12.4	6.9
Contractor fees	427	6.0	3.3
Subtotal	8,817	123.6	69.0
Contingency	1,763	24.7	13.8
Subtotal fixed investment	10,580	148.3	82.8
Allowance for startup and modifications	485	6.8	3.8
Interest during construction	1,270	17.8	10.0
Subtotal capital investment	12,335	172.9	96.6
Land	354	5.0	2.8
Working capital	85	1.2	0.6
Total capital investment	12,774	179.1	100.0

[a] Basis
New 200-MW plant (30-yr life); 316 klb/hr (15% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed independently of SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, pond acreage - 50% of optimum, 101 acres.

TABLE A-58. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 200-MW plant, constrained pond acreage - 50% of optimum)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	8.9
Maintenance				
Labor and materials				
4% of direct investment (plant)			56,300	2.3
3% of direct investment (pond)			171,800	7.0
Electricity	601 kkWh	0.031/kWh	18,600	0.8
Analyses	500 hr	17.00/hr	8,500	0.3
Subtotal conversion costs			474,200	19.3
Subtotal direct costs			474,200	19.3
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			740,100	30.0
Average cost of capital and taxes at 8.6% of total capital investment			1,098,600	44.6
Overhead				
Plant, 50% of conversion costs less utilities			127,600	5.2
Administrative, 10% of operating labor			21,900	0.9
Subtotal indirect costs			1,988,200	80.7
Total annual revenue requirements			2,462,400	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	14.81	7.41	1.76

a. Basis
Remaining plant life, 30 yr.
Coal burned, 175,238 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $12,774,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-59. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: constrained pond acreage, 200-MW plant)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	78	1.4	0.8
Piping and insulation	96	1.8	0.9
Transport lines	746	13.8	7.3
Foundation and structural	6	0.1	0.1
Excavation, site preparation, roads and railroads	66	1.2	0.6
Electrical	354	6.5	3.5
Instrumentation	41	0.8	0.4
Buildings	-	-	-
Subtotal	1,387	25.6	13.6
Services and miscellaneous	21	0.4	0.2
Subtotal excluding pond	1,408	26.0	13.8
Pond construction	4,010	74.0	39.3
Subtotal direct investment	5,418	100.0	53.1
Engineering design and supervision	274	5.1	2.7
Architect and engineering contractor	39	0.7	0.4
Construction expense	744	13.7	7.3
Contractor fees	347	6.4	3.4
Subtotal	6,822	125.9	66.9
Contingency	1,364	25.2	13.3
Subtotal fixed investment	8,186	151.1	80.2
Allowance for startup and modifications	418	7.7	4.1
Interest during construction	982	18.1	9.6
Subtotal capital investment	9,586	176.9	93.9
Land	532	9.8	5.2
Working capital	85	1.6	0.8
Total capital investment	10,203	188.3	100.0

[a] Basis
New 200-MW plant (30-yr life); 316 klb/hr (15% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed independently of SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, pond acreage - 75% of optimum, 152 acres.

TABLE A-60. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 200-MW plant, constrained pond acreage - 75% of optimum)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	10.8
Maintenance				
Labor and materials				
4% of direct investment (plant)			42,200	2.1
3% of direct investment (pond)			120,300	5.9
Electricity	1,906 kkWh	0.029/kWh	55,300	2.7
Analyses	500 hr	17.00/man-hr	8,500	0.4
Subtotal conversion costs			445,300	21.9
Subtotal direct costs			445,300	21.9
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			575,100	28.3
Average cost of capital and taxes at 8.6% of total capital investment			877,500	43.2
Overhead				
Plant, 50% of conversion costs less utilities			113,200	5.6
Administrative. 10% of operating labor			21,900	1.1
Subtotal indirect costs			1,587,700	78.1
Total annual revenue requirements			2,033,000	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	12.23	6.12	1.45	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 175,238 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $10,203,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-61. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: constrained pond acreage, 500-MW plant)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	128	1.0	0.6
Piping and insulation	121	0.9	0.5
Transport lines	1,109	8.4	4.9
Foundation and structural	7	0.1	0.1
Excavation, site preparation, roads and railroads	73	0.6	0.3
Electrical	395	3.0	1.7
Instrumentation	53	0.4	0.2
Buildings	-	-	-
Subtotal	1,886	14.4	8.3
Services and miscellaneous	28	0.2	0.1
Subtotal excluding pond	1,914	14.6	8.4
Pond construction	11,179	85.4	49.3
Subtotal direct investment	13,093	100.0	57.7
Engineering design and supervision	464	3.5	2.0
Architect and engineering contractor	58	0.4	0.3
Construction expense	1,393	10.7	6.2
Contractor fees	678	5.2	3.0
Subtotal	15,686	119.8	69.2
Contingency	3,137	24.0	13.8
Subtotal fixed investment	18,823	143.8	83.0
Allowance for startup and modifications	764	5.8	3.4
Interest during construction	2,259	17.3	9.9
Subtotal capital investment	21,846	166.9	96.3
Land	714	5.4	3.2
Working capital	116	0.9	0.5
Total capital investment	22,676	173.2	100.0

a. Basis

New 500-MW plant (30-yr life); 772 klb/hr (15% solids) sludge.
Midwest plant location, average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, pond acreage - 50% of optimum, 204 acres.

TABLE A-62. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: constrained pond acreage - 50% of optimum)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	5.2
Maintenance				
Labor and materials				
4% of direct investment (plant)			76,600	1.8
3% of direct investment (pond)			335,400	8.0
Electricity	1,906 kkWh	0.029/kWh	55,300	1.3
Analyses	500 hr	17.00/man-hr	8,500	0.2
Subtotal conversion costs			694,800	16.5
Subtotal direct costs			694,800	16.5
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,310,800	31.1
Average cost of capital and taxes at 8.6% of total capital investment			1,950,100	46.3
Overhead				
Plant, 50% of conversion costs less utilities			237,900	5.6
Administrative, 10% of operating labor			21,900	0.5
Subtotal indirect costs			3,472,500	83.5
Total annual revenue requirements			4,215,500	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	10.15	5.08	1.18

a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment $22,676,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-63. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: constrained pond acreage, 500-MW plant)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	128	1.3	0.7
Piping and insulation	121	1.2	0.7
Transport lines	1,109	11.2	6.1
Foundation and structural	7	0.1	0.1
Excavation, site preparation, roads and railroads	73	0.7	0.4
Electrical	395	4.0	2.2
Instrumentation	53	0.6	0.3
Buildings	-	-	-
Subtotal	1,886	19.1	10.5
Services and miscellaneous	28	0.3	0.1
Subtotal excluding pond	1,914	19.4	10.6
Pond construction	7,965	80.6	44.3
Subtotal direct investment	9,879	100.0	54.9
Engineering design and supervision	386	3.9	2.1
Architect and engineering contractor	51	0.5	0.3
Construction expense	1,157	11.8	6.5
Contractor fees	547	5.5	3.0
Subtotal	12,020	121.7	66.8
Contingency	2,404	24.3	13.4
Subtotal fixed investment	14,424	146.0	80.2
Allowance for startup and modifications	646	6.5	3.6
Interest during construction	1,731	17.6	9.6
Subtotal capital investment	16,801	170.1	93.4
Land	1,068	10.8	6.0
Working capital	116	1.2	0.6
Total capital investment	17,985	182.1	100.0

[a] Basis
New 500-MW plant (30-yr life); 772 klb/hr (15% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, pond acreage - 75% of optimum, 305 acres.

TABLE A-64. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: constrained pond acreage - 75% of optimum)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	6.5
Maintenance				
Labor and materials				
4% of direct investment (plant)			76,600	2.3
3% of direct investment (pond)			239,000	7.1
Electricity	1,906 kkWh	0.029/kWh	55,300	1.6
Analyses	500 hr	17.00/man-hr	8,500	0.3
Subtotal conversion costs			598,400	17.8
Subtotal direct costs			598,400	17.8
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,008,100	30.0
Average cost of capital and taxes at 8.6% of total capital investment			1,546,700	46.0
Overhead				
Plant, 50% of conversion costs less utilities			189,700	5.6
Administrative, 10% of operating labor			21,900	0.7
Subtotal indirect costs			2,766,400	82.2
Total annual revenue requirements			3,364,800	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	8.29	4.15	0.96

a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $17,985,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-65. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: constrained pond acreage, 1500-MW plant)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	237	0.8	0.5
Piping and insulation	207	0.7	0.4
Transport lines	1,922	6.5	3.9
Foundation and structural	14	0.1	0.1
Excavation, site preparation, roads and railroads	77	0.3	0.2
Electrical	522	1.8	1.0
Instrumentation	53	0.2	0.1
Buildings	-	-	-
Subtotal	3,032	10.4	6.2
Services and miscellaneous	45	0.2	0.1
Subtotal excluding pond	3,077	10.6	6.3
Pond construction	26,144	89.4	53.4
Subtotal direct investment	29,221	100.0	59.7
Engineering design and supervision	758	2.6	1.5
Architect and engineering contractor	88	0.3	0.2
Construction expense	2,586	8.8	5.3
Contractor fees	1,248	4.3	2.6
Subtotal	33,901	116.0	69.3
Contingency	6,780	23.2	13.9
Subtotal fixed investment	40,681	139.2	83.2
Allowance for startup and modifications	1,454	5.0	3.0
Interest during construction	4,882	16.7	10.0
Subtotal capital investment	47,017	160.9	96.2
Land	1,680	5.7	3.4
Working capital	220	0.8	0.4
Total capital investment	48,917	167.4	100.0

a. Basis
New 1500-MW plant (30-yr life); 2,368 klb/hr (15% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, pond acreage - 50% of optimum, 380 acres.

TABLE A-66. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 1500-MW plant, constrained pond acreage - 50% of optimum)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	26,280 man-hr	12.50/man-hr	328,500	3.7
Maintenance				
Labor and materials				
4% of direct investment (plant)			123,100	1.4
3% of direct investment (pond)			784,300	8.7
Electricity	5,170 kkWh	0.027/kWh	139,600	1.6
Analyses	1,000 hr	17.00/man-hr	17,000	0.2
Subtotal conversion costs			1,392,500	15.5
Subtotal direct costs			1,392,500	15.5
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			2,821,000	31.4
Average cost of capital and taxes at 8.6% of total capital investment			4,206,900	46.8
Overhead				
Plant, 50% of conversion costs less utilities			532,000	5.9
Administrative, 10% of operating labor			32,900	0.4
Subtotal indirect costs			7,592,800	84.5
Total annual revenue requirements			8,985,300	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	7.40	3.70	0.86	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 1,285,714 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $48,917,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-67. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: constrained pond acreage, 1500-MW plant)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	237	1.1	0.6
Piping and insulation	207	1.0	0.5
Transport lines	1,922	8.9	5.0
Foundation and structural	14	0.1	0.1
Excavation, site preparation, roads and railroads	77	0.3	0.2
Electrical	522	2.4	1.4
Instrumentation	53	0.2	0.1
Buildings	-	-	-
Subtotal	3,032	14.0	7.9
Services and miscellaneous	45	0.2	0.1
Subtotal excluding pond	3,077	14.2	8.0
Pond construction	18,637	85.8	48.8
Subtotal direct investment	21,714	100.0	56.8
Engineering design and supervision	620	2.9	1.6
Architect and engineering contractor	74	0.3	0.2
Construction expense	2,109	9.7	5.5
Contractor fees	996	4.6	2.6
Subtotal	25,513	117.5	66.7
Contingency	5,103	23.5	13.4
Subtotal fixed investment	30,616	141.0	80.1
Allowance for startup and modifications	1,198	5.5	3.1
Interest during construction	3,674	16.9	9.6
Subtotal capital investment	35,488	163.4	92.8
Land	2,520	11.6	6.6
Working capital	220	1.0	0.6
Total capital investment	38,228	176.0	100.0

a. Basis
New 1500-MW plant (30-yr life); 2,368 klb/hr (15% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, pond acreage - 75% of optimum, 571 acres.

TABLE A-68. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 1500-MW plant, constrained pond acreage - 75% of optimum)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	26,280 man-hr	12.50/man-hr	328,500	4.7
Maintenance				
Labor and materials				
4% of direct investment (plant)			123,100	1.7
3% of direct investment (pond)			559,100	7.9
Electricity	5,170 kkWh	0.027/kWh	139,600	2.0
Analyses	1,000 hr	17.00/man-hr	17,000	0.2
Subtotal conversion costs			1,167,300	16.6
Subtotal direct costs			1,167,300	16.6
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			2,129,300	30.3
Average cost of capital and taxes at 8.6% of total capital investment			3,287,600	46.7
Overhead				
Plant, 50% of conversion costs less utilities			419,400	6.0
Administrative, 10% of operating labor			32,900	0.5
Subtotal indirect costs			5,869,200	83.4
Total annual revenue requirements			7,036,500	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	6.05	3.03	0.67	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 1,285,714 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $38,228,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-69. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: pond settled density 40%)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	129	1.2	0.6
Piping and insulation	121	1.1	0.6
Transport lines	1,109	10.2	5.4
Foundation and structural	7	0.1	0.1
Excavation, site preparation, roads and railroads	73	0.7	0.4
Electrical	395	3.7	2.0
Instrumentation	53	0.5	0.3
Buildings	-	-	-
Subtotal	1,887	17.5	9.4
Services and miscellaneous	28	0.3	0.1
Subtotal excluding pond	1,915	17.8	9.5
Pond construction	8,848	82.2	44.1
Subtotal direct investment	10,763	100.0	53.6
Engineering design and supervision	408	3.8	2.0
Architect and engineering contractor	53	0.5	0.3
Construction expense	1,223	11.4	6.1
Contractor fees	584	5.4	2.9
Subtotal	13,031	121.1	64.9
Contingency	2,606	24.2	13.0
Subtotal fixed investment	15,637	145.3	77.9
Allowance for startup and modifications	697	6.5	3.5
Interest during construction	1,876	17.4	9.3
Subtotal capital investment	18,210	169.2	90.7
Land	1,735	16.1	8.7
Working capital	125	1.2	0.6
Total capital investment	20,070	186.5	100.0

[a] Basis
New 500-MW plant (30-yr life); 772 klb/hr (15% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 40% solids settled density, 21.21 ft total depth, 496 acres.

TABLE A-70. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 40% solids settled density)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	5.9
Maintenance				
Labor and materials				
4% of direct investment (plant)			76,600	2.0
3% of direct investment (pond)			265,400	7.1
Electricity	1,906 kkWh	0.029/kWh	55,300	1.5
Analyses	500 hr	17.00/hr	8,500	0.2
Subtotal conversion costs			624,800	16.7
Subtotal direct costs			624,800	16.7
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,091,500	29.1
Average cost of capital and taxes at 8.6% of total capital investment			1,724,500	46.0
Overhead				
Plant, 50% of conversion costs less utilities			284,700	7.6
Administrative, 10% of operating labor			21,900	0.6
Subtotal indirect costs			3,122,600	83.3
Total annual revenue requirements			3,747,400	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	11.54	5.77	1.07	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $20,070,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-71. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: pond settled density 60%)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	128	1.6	0.8
Piping and insulation	121	1.5	0.8
Transport lines	1,109	13.8	7.3
Foundation and structural	7	0.1	0.1
Excavation, site preparation, roads and railroads	73	0.9	0.5
Electrical	395	4.9	2.6
Instrumentation	53	0.7	0.3
Buildings	-	-	-
Subtotal	1,886	23.5	12.4
Services and miscellaneous	28	0.3	0.2
Subtotal excluding pond	1,914	23.8	12.6
Pond construction	6,125	76.2	40.3
Subtotal direct investment	8,039	100.0	52.9
Engineering design and supervision	337	4.2	2.2
Architect and engineering contractor	46	0.6	0.3
Construction expense	1,014	12.6	6.7
Contractor fees	468	5.8	3.1
Subtotal	9,904	123.2	65.2
Contingency	1,981	24.6	13.0
Subtotal fixed investment	11,885	147.8	78.2
Allowance for startup and modifications	576	7.2	3.8
Interest during construction	1,426	17.7	9.4
Subtotal capital investment	13,887	172.7	91.4
Land	1,198	14.9	7.9
Working capital	109	1.4	0.7
Total capital investment	15,194	189.0	100.0

a. Basis
New 500-MW plant (30-yr life); 772 klb/hr (15% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 60% solids settled density, 20.40 ft total depth, 342 acres.

TABLE A-72. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 60% solids settled density)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	7.4
Maintenance				
Labor and materials				
4% of direct investment (plant)			76,600	2.6
3% of direct investment (pond)			183,800	6.2
Electricity	1,906 kkWh	0.029/kWh	55,300	1.9
Analyses	500 hr	17.00/hr	8,500	0.3
Subtotal conversion costs			543,200	18.4
Subtotal direct costs			543,200	18.4
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			833,200	28.3
Average cost of capital and taxes at 8.6% of total capital investment			1,306,700	44.3
Overhead				
Plant, 50% of conversion costs less utilities			243,900	8.3
Administrative, 10% of operating labor			21,900	0.7
Subtotal indirect costs			2,405,700	81.6
Total annual revenue requirements			2,948,900	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	6.05	3.03	1.66	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $15,194,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-73. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: unlined pond)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	128	1.8	0.9
Piping and insulation	121	1.7	0.8
Transport lines	1,109	15.3	7.7
Foundation and structural	7	0.1	0.1
Excavation, site preparation, roads and railroads	73	1.0	0.5
Electrical	395	5.5	2.7
Instrumentation	53	0.7	0.4
Buildings	-	-	-
Subtotal	1,886	26.1	13.1
Services and miscellaneous	28	0.4	0.2
Subtotal excluding pond	1,914	26.5	13.1
Pond construction	5,311	73.5	36.9
Subtotal direct investment	7,225	100.0	50.2
Engineering design and supervision	313	4.3	2.2
Architect and engineering contractor	43	0.6	0.3
Construction expense	948	13.1	6.6
Contractor fees	432	6.0	3.0
Subtotal	8,961	124.0	62.3
Contingency	1,792	24.8	12.4
Subtotal fixed investment	10,753	148.8	74.7
Allowance for startup and modifications	544	7.5	3.8
Interest during construction	1,290	17.9	9.0
Subtotal capital investment	12,587	174.2	87.5
Land	1,700	23.6	11.8
Working capital	104	1.4	0.7
Total capital investment	14,391	199.2	100.0

a. Basis

New 500-MW plant (30-yr life); 772 klb/hr (15% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: unlined pond, 1 mi from scrubber facilities, 50% solids settled density, 17.20 ft total depth, 486 acres.

TABLE A-74. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: unlined pond)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	7.9
Maintenance				
Labor and materials				
4% of direct investment (plant)			76,600	2.8
3% of direct investment (pond)			159,300	5.8
Electricity	1,906 kkWh	0.029/kWh	55,300	2.0
Analyses	500 hr	17.00/hr	8,500	0.3
Subtotal conversion costs			518,700	18.8
Subtotal direct costs			518,700	18.8
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			755,200	27.3
Average cost of capital and taxes at 8.6% of total capital investment			1,237,600	44.7
Overhead				
Plant, 50% of conversion costs less utilities			231,700	8.4
Administrative, 10% of operating labor			21,900	0.8
Subtotal indirect costs			2,246,400	81.2
Total annual revenue requirements			2,765,100	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	6.81	3.41	0.79	

a. **Basis**
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $14,391,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-75. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: synthetic lining, \$1.50/yd^2)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	128	1.1	0.6
Piping and insulation	121	1.0	0.6
Transport lines	1,109	9.4	5.2
Foundation and structural	7	0.1	0.1
Excavation, site preparation, roads and railroads	73	0 6	0.3
Electrical	395	3.4	1.9
Instrumentation	53	0.4	0.3
Buildings	-	-	-
Subtotal	1,886	16.1	9.0
Services and miscellaneous	28	0.2	0.1
Subtotal excluding pond	1,914	16.3	9.1
Pond construction	9,818	83.7	46.8
Subtotal direct investment	11,732	100.0	55.9
Engineering design and supervision	432	3.7	2.0
Architect and engineering contractor	55	0.5	0.3
Construction expense	1,295	11.0	6.1
Contractor fees	624	5.3	3.0
Subtotal	14,138	120.5	67.3
Contingency	2,828	24.1	13.5
Subtotal fixed investment	16,966	144.6	80.8
Allowance for startup and modifications	715	6.1	3.4
Interest during construction	2,036	17.4	9.7
Subtotal capital investment	19,717	168.1	93.9
Land	1,133	9.6	5.4
Working capital	144	1.2	0.7
Total capital investment	20,994	178.9	100.0

a. Basis
New 500-MW plant (30-yr life); 772 klb/hr (15% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: synthetic lining, 1 mi from scrubber facilities, 50% solids settled density, 21.21 ft total depth, 407 acres.

TABLE A-76. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: synthetic-lined pond, cost $1.50/yd^2)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	5.6
Maintenance				
Labor and materials				
4% of direct investment (plant)			76,600	2.0
3% of direct investment (pond)			294,500	7.6
Electricity	1,906 kkWh	0.029/kWh	55,300	1.4
Analyses	500 hr	17.00/hr	8,500	0.2
Subtotal conversion costs			653,900	16.8
Subtotal direct costs			653,900	16.8
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,183,000	30.5
Average cost of capital and taxes at 8.6% of total capital investment			1,805,500	46.5
Overhead				
Plant, 50% of conversion costs less utilities			217,500	5.6
Administrative, 10% of operating labor			21,900	0.6
Subtotal indirect costs			3,227,900	83.2
Total annual revenue requirements			3,881,800	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	9.50	4.75	1.11	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $20,994,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-77. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: synthetic lining, \$2.50/yd^2)

	Total, k\$	Percent of direct investment	Percent of total capital investment
Process equipment	128	1.0	0.6
Piping and insulation	121	0.9	0.5
Transport lines	1,109	8.5	4.8
Foundation and structural	7	0.1	0.1
Excavation, site preparation, roads and railroads	73	0.5	0.3
Electrical	395	3.0	1.7
Instrumentation	53	0.4	0.2
Buildings	-	-	-
Subtotal	1,886	14.4	8.2
Services and miscellaneous	28	0.2	0.1
Subtotal excluding pond	1,914	14.6	8.3
Pond construction	11,202	85.4	48.6
Subtotal direct investment	13,116	100.0	56.9
Engineering design and supervision	465	3.5	2.0
Architect and engineering contractor	58	0.4	0.2
Construction expense	1,395	10.6	6.1
Contractor fees	679	5.2	2.9
Subtotal	15,713	119.8	68.1
Contingency	3,143	24.0	13.6
Subtotal fixed investment	18,856	143.8	81.7
Allowance for startup and modifications	765	5.8	3.3
Interest during construction	2,263	17.2	9.9
Subtotal capital investment	21,884	166.8	94.9
Land	1,042	7.9	4.5
Working capital	144	1.1	0.6
Total capital investment	23,070	175.9	100.0

a. Basis
New 500-MW plant (30-yr life); 772 klb/hr (15% solids) sludge.
Midwest plant location, average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: synthetic lining, 1 mi from scrubber facilities, 50% solids settled density, 21.21 ft total depth, 407 acres.

TABLE A-78. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: synthetic-lined pond - cost $\$2.50/yd^2$)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	5.1
Maintenance				
Labor and materials				
4% of direct investment (plant)			76,600	1.8
3% of direct investment (pond)			336,000	7.9
Electricity	1,906 kkWh	0.029/kWh	55,300	1.3
Analyses	500 hr	17.00/hr	8,500	0.2
Subtotal conversion costs			695,400	16.3
Subtotal direct costs			695,400	16.3
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,313,000	30.9
Average cost of capital and taxes at 8.6% of total capital investment			1,984,000	46.7
Overhead				
Plant, 50% of conversion costs less utilities			238,200	5.6
Administrative, 10% of operating labor			21,900	0.5
Subtotal indirect costs			3,557,100	83.7
Total annual revenue requirements			4,252,500	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	10.47	5.24	1.21	

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a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $23,070,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-79. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: synthetic lining, \$3.50/yd^2)

	Total, k\$	Percent of direct investment	Percent of total capital investment
Process equipment	128	0.9	0.5
Piping and insulation	121	0.8	0.5
Transport lines	1,109	7.7	4.4
Foundation and structural	7	0.1	0.1
Excavation, site preparation, roads and railroads	73	0.5	0.3
Electrical	395	2.7	1.6
Instrumentation	53	0.4	0.2
Buildings	-	-	-
Subtotal	1,886	13.1	7.6
Services and miscellaneous	28	0.2	0.1
Subtotal excluding pond	1,914	13.3	7.7
Pond construction	12,459	86.7	49.9
Subtotal direct investment	14,373	100.0	57.6
Engineering design and supervision	493	3.4	2.0
Architect and engineering contractor	61	0.4	0.2
Construction expense	1,484	10.3	6.0
Contractor fees	728	5.1	2.9
Subtotal	17,139	119.2	68.7
Contingency	3,428	23.9	13.7
Subtotal fixed investment	20,567	143.1	82.4
Allowance for startup and modifications	811	5.6	3.2
Interest during construction	2,468	17.2	9.9
Subtotal capital investment	23,846	165.9	95.5
Land	969	6.7	3.9
Working capital	144	1.0	0.6
Total capital investment	24,959	173.6	100.0

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a. Basis
New 500-MW plant (30-yr life); 772 klb/hr (15% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: synthetic lining, 1 mi from scrubber facilities, 50% solids settled density, 21.21 ft total depth, 407 acres.

TABLE A-80. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: synthetic-lined pond - cost $\$3.50/yd^2$)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	4.8
Maintenance				
Labor and materials				
4% of direct investment (plant)			76,600	1.7
3% of direct investment (pond)			373,800	8.1
Electricity	1,906 kkWh	0.029/kWh	55,300	1.2
Analyses	500 hr	17.00/hr	8,500	0.2
Subtotal conversion costs			733,200	16.0
Subtotal direct costs			733,200	16.0
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,430,800	31.2
Average cost of capital and taxes at 8.6% of total capital investment			2,146,500	46.8
Overhead				
Plant, 50% of conversion costs less utilities			257,100	5.6
Administrative, 10% of operating labor			21,900	0.5
Subtotal indirect costs			3,856,300	84.0
Total annual revenue requirements			4,589,500	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	11.30	5.65	1.31	

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a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $24,959,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-81. UNTREATED DISPOSAL[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: synthetic lining, \$4.50/yd^2)

	Total, k\$	Percent of direct investment	Percent of total capital investment
Process equipment	128	0.8	0.5
Piping and insulation	121	0.8	0.4
Transport lines	1,109	7.1	4.1
Foundation and structural	7	0.1	0.1
Excavation, site preparation, roads and railroads	73	0.5	0.3
Electrical	395	2.5	1.5
Instrumentation	53	0.3	0.2
Buildings	-	-	-
Subtotal	1,886	12.1	7.1
Services and miscellaneous	28	0.2	0.1
Subtotal excluding pond	1,914	12.3	7.2
Pond construction	13,616	87.7	51.0
Subtotal direct investment	15,530	100.0	58.2
Engineering design and supervision	518	3.3	1.9
Architect and engineering contractor	64	0.4	0.2
Construction expense	1,565	10.1	5.9
Contractor fees	772	5.0	2.9
Subtotal	18,449	118.8	69.1
Contingency	3,690	23.8	13.8
Subtotal fixed investment	22,139	142.6	82.9
Allowance for startup and modifications	852	5.5	3.2
Interest during construction	2,657	17.1	9.9
Subtotal capital investment	25,648	165.2	96.0
Land	915	5.9	3.5
Working capital	144	0.9	0.5
Total capital investment	26,707	172.0	100.0

a. Basis

New 500-MW plant (30-yr life); 772 klb/hr (15% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: synthetic lining, 1 mi from scrubber facilities, 50% solids settled density, 21.21 ft total depth, 407 acres.

TABLE A-82. UNTREATED DISPOSAL[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: synthetic-lined pond - cost $4.50/yd^2)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Conversion costs				
Operating labor and supervision	17,520 man-hr	12.50/man-hr	219,000	4.5
Maintenance				
Labor and materials				
4% of direct investment (plant)			76,600	1.6
3% of direct investment (pond)			408,500	8.3
Electricity	1,906 kkWh	0.029/kWh	55,300	1.1
Analyses	500 hr	17.00/hr	8,500	0.2
Subtotal conversion costs			767,900	15.7
Subtotal direct costs			767,900	15.7
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,538,900	31.4
Average cost of capital and taxes at 8.6% of total capital investment			2,296,800	46.9
Overhead				
Plant, 50% of conversion costs less utilities			274,500	5.6
Administrative, 10% of operating labor			21,900	0.4
Subtotal indirect costs			4,132,100	84.3
Total annual revenue requirements			4,900,000	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	17.07	6.04	1.40

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a. **Basis**
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $26,707,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-83. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Base case)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,272	18.4	9.4
Piping and insulation	262	2.1	1.1
Transport lines	657	5.3	2.7
Foundation and structural	313	2.5	1.3
Excavation, site preparation, roads and railroads	164	1.3	0.7
Electrical	974	7.9	4.0
Instrumentation	113	0.9	0.5
Buildings	115	0.9	0.5
Subtotal	4,870	39.4	20.2
Services and miscellaneous	73	0.6	0.3
Subtotal excluding pond	4,943	40.0	20.5
Pond construction	7,410	60.0	30.7
Subtotal direct investment	12,353	100.0	51.2
Engineering design and supervision	821	6.6	3.4
Architect and engineering contractor	162	1.3	0.7
Construction expense	1,627	13.2	6.7
Contractor fees	649	5.3	2.7
Subtotal	15,612	126.4	64.7
Contingency	3,122	25.3	13.0
Subtotal fixed investment	18,734	151.7	77.7
Allowance for startup and modifications	1,132	9.2	4.7
Interest during construction	2,248	18.1	9.3
Subtotal capital investment	22,114	179.0	91.7
Land	1,450	11.7	6.0
Working capital	550	4.5	2.3
Total capital investment	24,114	195.2	100.0

a. Basis
New 500-MW plant (30-yr life); 347 klb/hr (36% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 21.38 ft total depth, 414 acres.
Calcilox added at 7% of dry solids.

TABLE A-84. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Base case)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	4,053 tons	48.00/ton	194,500	2.9
Calcilox	28,378 tons	58.00/ton	1,645,900	24.6
Subtotal raw materials cost			1,840,400	27.5
Conversion costs				
Operating labor and supervision	35,040 man-hr	12.50/man-hr	438,000	6.5
Maintenance				
Labor and materials				
4% of direct investment (plant)			197,700	3.0
3% of direct investment (pond)			222,300	3.3
Electricity	3,577 kkWh	.029/kWh	103,700	1.6
Analyses	1,000 hr	17.00/hr	17,000	0.2
Subtotal conversion costs			978,700	14.6
Subtotal direct costs			2,819,100	42.1
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,326,800	19.8
Average cost of capital and taxes at 8.6% of total capital investment			2,073,800	31.0
Overhead				
Plant, 50% of conversion costs less utilities			437,500	6.5
Administrative, 10% of operating labor			43,800	0.6
Subtotal indirect costs			3,881,900	57.9
Total annual revenue requirements			6,701,000	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	15.32	7.66	1.91	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $24,114,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-85. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: 200-MW plant)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	1,405	20.5	10.2
Piping and insulation	179	2.6	1.3
Transport lines	451	6.6	3.2
Foundation and structural	116	1.7	0.8
Excavation, site preparation, roads and railroads	141	2.1	1.0
Electrical	795	10.6	5.7
Instrumentation	100	1.5	0.7
Buildings	115	1.7	0.8
Subtotal	3,302	48.3	23.7
Services and miscellaneous	50	0.8	0.3
Subtotal excluding pond	3,352	49.1	24.0
Pond construction	3,479	50.9	25.0
Subtotal direct investment	6,831	100.0	49.0
Engineering design and supervision	682	10.0	4.9
Architect and engineering contractor	144	2.1	1.0
Construction expense	1,048	15.3	7.5
Contractor fees	414	6.1	3.0
Subtotal	9,119	133.5	65.4
Contingency	1,824	26.7	13.1
Subtotal fixed investment	10,943	160.2	78.5
Allowance for startup and modifications	746	10.9	5.4
Interest during construction	1,313	19.2	9.4
Subtotal capital investment	13,002	190.3	93.3
Land	676	9.9	4.8
Working capital	264	3.9	1.9
Total capital investment	13,942	204.1	100.0

a. Basis

New 200-MW plant (30-yr life); 141 klb/hr (36% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO$_2$.
SO$_2$ and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO$_2$ removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 17.87 ft total depth, 193 acres.
Calcilox added at 7% of dry solids.

TABLE A-86. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 200-MW plant)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	1,519 tons	48.00/ton	72,900	2.0
Calcilox	10,623 tons	58.00/ton	616,100	16.9
Subtotal raw materials cost			689,000	18.9
Conversion costs				
Operating labor and supervision	25,280 man-hr	12.50/man-hr	328,500	9.0
Maintenance				
Labor and materials				
4% of direct investment (plant)			134,100	3.7
3% of direct investment (pond)			104,400	2.9
Electricity	2,130 kkWh	0.031/kWh	66,000	1.8
Analyses	1,000 hr	17.00/man-hr	17,000	0.5
Subtotal conversion costs			650,000	17.9
Subtotal direct costs			1,339,000	36.8
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			780,100	21.4
Average cost of capital and taxes at 8.6% of total capital investment			1,199,000	32.9
Overhead				
Plant, 50% of conversion costs less utilities			292,000	8.0
Administrative, 10% of operating labor			32,900	0.9
Subtotal indirect costs			2,304,000	63.2
Total annual revenue requirements			3,643,000	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	20.41	10.21	2.60	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 175,238 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $13,942,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-87. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 200-MW plant, 25-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	1,503	23.3	11.3
Piping and insulation	187	2.9	1.4
Transport lines	451	7.0	3.4
Foundation and structural	119	1.8	0.9
Excavation, site preparation, roads and railroads	146	2.3	1.1
Electrical	798	12.3	6.0
Instrumentation	100	1.5	0.8
Buildings	115	1.8	0.9
Subtotal	3,419	52.9	25.8
Services and miscellaneous	51	0.8	0.4
Subtotal excluding pond	3,470	53.7	26.2
Pond construction	2,990	46.3	22.5
Subtotal direct investment	6,460	100.0	48.7
Engineering design and supervision	654	10.1	4.9
Architect and engineering contractor	140	2.2	1.1
Construction expense	1,025	15.9	7.7
Contractor fees	396	6.1	3.0
Subtotal	8,675	134.3	65.4
Contingency	1,735	26.8	13.1
Subtotal fixed investment	10,410	161.1	78.5
Allowance for startup and modifications	742	11.5	5.6
Interest during construction	1,249	19.4	9.4
Subtotal capital investment	12,401	192.0	93.5
Land	578	8.9	4.4
Working capital	279	4.3	2.1
Total capital investment	13,258	205.2	100.0

a. Basis
Existing 200-MW plant (25-yr remaining life); 146 klb/hr (36% solids) sludge: Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 17.33 ft total depth, 165 acres.
Calcilox added at 7% of dry solids.

TABLE A-88. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 200-MW plant, 25 yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	1,712 tons	48.00/ton	82,200	2.3
Calcilox	11,981 tons	58.00/ton	694,900	18.9
Subtotal raw materials cost			777,100	21.2
Conversion costs				
Operating labor and supervision	25,280 man-hr	12.50/man-hr	328,500	9.0
Maintenance				
Labor and materials				
4% of direct investment (plant)			138,800	3.8
3% of direct investment (pond)			89,700	2.4
Electricity	2,177 kkWh	0.031/kWh	67,500	1.8
Analyses	1,000 hr	17.00/man-hr	17,000	0.5
Subtotal conversion costs			541,500	17.5
Subtotal direct costs			1,418,600	38.6
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6.4% of total capital investment less land and working capital			793,700	21.6
Average cost of capital and taxes at 8.6% of total capital investment			1,140,200	31.1
Overhead				
Plant, 50% of conversion costs less utilities			287,000	7.8
Administrative, 10% of operating labor			32,900	0.9
Subtotal indirect costs			2,253,800	61.4
Total annual revenue requirements			3,672,400	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	19.87	9.94	2.62	

a. Basis
Remaining plant life, 25 yr.
Coal burned, 180,952 lb/hr, 9,500 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $13,258,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-89. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 200-MW plant, 20-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	1,503	27.0	12.9
Piping and insulation	187	3.4	1.6
Transport lines	451	8.1	3.9
Foundation and structural	119	2.2	1.0
Excavation, site preparation, roads and railroads	146	2.6	1.3
Electrical	798	14.3	6.9
Instrumentation	100	1.8	0.9
Buildings	115	2.1	1.0
Subtotal	3,419	61.5	29.5
Services and miscellaneous	51	0.9	0.4
Subtotal excluding pond	3,470	62.4	29.9
Pond construction	2,093	37.6	18.1
Subtotal direct investment	5,563	100.0	48.0
Engineering design and supervision	620	11.1	5.3
Architect and engineering contractor	136	2.4	1.2
Construction expense	942	17.0	8.1
Contractor fees	354	6.4	3.1
Subtotal	7,615	136.9	65.7
Contingency	1,523	27.4	13.1
Subtotal fixed investment	9,138	164.3	78.8
Allowance for startup and modifications	705	12.7	6.1
Interest during construction	1,097	19.7	9.4
Subtotal capital investment	10,940	196.7	94.3
Land	384	6.9	3.3
Working capital	273	4.9	2.4
Total capital investment	11,597	208.5	100.0

a. Basis

Existing 200-MW plant (20-yr remaining life); 146 klb/hr (36% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979.

Coal analysis (by wt): 3.5% S (dry basis), 16% ash.

Flyash removed with SO_2.

SO_2 and flyash removed to meet NSPS.

Limestone process with 1.5 stoichiometry based on SO_2 removed.

Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 16.86 ft total depth, 110 acres.

Calcilox added at 7% of dry solids.

TABLE A-90. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 200-MW plant, 20-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	1,712 tons	48.00/ton	82,200	2.4
Calcilox	11,981 tons	58.00/ton	694,900	20.1
Subtotal raw materials cost			777,100	22.5
Conversion costs				
Operating labor and supervision	25,280 man-hr	12.50/man-hr	328,500	9.5
Maintenance				
Labor and materials				
4% of direct investment (plant)			138,800	4.0
3% of direct investment (pond)			62,800	1.8
Electricity	2,177 kkWh	0.031/kWh	67,500	1.9
Analyses	1,000 hr	17.00/man-hr	17,000	0.5
Subtotal conversion costs			614,600	17.7
Subtotal direct costs			1,391,700	40.2
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance [illegible]7% of total capital investment less land and working capital			765,800	22.1
Average cost of capital and taxes at 8.6% of total capital investment			997,300	28.8
Overhead				
Plant, 50% of conversion costs less utilities			273,600	7.9
Administrative, 10% of operating labor			32,900	1.0
Subtotal indirect costs			2,069,600	59.8
Total annual revenue requirements			3,451,300	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	18.37	9.37	2.47

a. Basis
Remaining plant life, 20 yr.
Coal burned, 180,952 lb/hr, 9,500 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $11,597,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-91. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 200-MW plant, 15-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	1,503	31.2	14.7
Piping and insulation	187	3.9	1.8
Transport lines	451	9.4	4.4
Foundation and structural	119	2.5	1.2
Excavation, site preparation, roads and railroads	146	3.0	1.4
Electrical	798	16.6	7.8
Instrumentation	100	2.1	1.0
Buildings	115	2.4	1.1
Subtotal	3,419	70.9	33.4
Services and miscellaneous	51	1.1	0.5
Subtotal excluding pond	3,470	72.0	33.9
Pond construction	1,349	28.0	13.2
Subtotal direct investment	4,819	100.0	47.1
Engineering design and supervision	588	12.2	5.7
Architect and engineering contractor	133	2.8	1.3
Construction expense	869	18.0	8.5
Contractor fees	317	6.6	3.1
Subtotal	6,726	139.6	65.7
Contingency	1,345	27.9	13.1
Subtotal fixed investment	8,071	167.5	78.8
Allowance for startup and modifications	672	13.9	6.6
Interest during construction	969	20.1	9.5
Subtotal capital investment	9,712	201.5	94.9
Land	258	5.4	2.5
Working capital	269	5.6	2.6
Total capital investment	10,239	212.5	100.0

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a. Basis

Existing 200-MW plant (15-yr remaining life); 146 klb/hr (36% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979.

Coal analysis (by wt): 3.5% S (dry basis), 16% ash.

Flyash removed with SO_2.

SO_2 and flyash removed to meet NSPS.

Limestone process with 1.5 stoichiometry based on SO_2 removed.

Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 14.57 ft total depth, 74 acres.

Calcilox added at 7% of dry solids.

TABLE A-92. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 200-MW plant, 15-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	1,712 tons	48.00/ton	82,200	2.4
Calcilox	11,981 tons	58.00/ton	694,900	20.5
Subtotal raw materials cost			777,100	22.9
Conversion costs				
Operating labor and supervision	26,280 man-hr	12.50/man-hr	328,500	9.7
Maintenance				
Labor and materials				
4% of direct investment (plant)			138,800	4.1
3% of direct investment (pond)			40,500	1.2
Electricity	2,177 kkWh	0.031/kWh	67,500	2.0
Analyses	1,000 hr	17.00/man-hr	17,000	0.5
Subtotal conversion costs			592,300	17.5
Subtotal direct costs			1,369,400	40.4
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 8.7% of total capital investment less land and working capital			844,900	24.9
Average cost of capital and taxes at 8.6% of total capital investment			880,600	26.0
Overhead				
Plant, 50% of conversion costs less utilities			262,400	7.7
Administrative, 10% of operating labor			32,900	1.0
Subtotal indirect costs			2,020,800	59.6
Total annual revenue requirements			3,390,200	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	18.35	9.18	2.42	

a. Basis
Remaining plant life, 15 yr.
Coal burned, 180,952 lb/hr, 9,500 Btu/hr.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $10,239,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-93. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 500-MW plant, 25-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,275	21.0	10.6
Piping and insulation	262	2.4	1.2
Transport lines	657	6.1	3.1
Foundation and structural	313	2.9	1.5
Excavation, site preparation, roads and railroads	167	1.5	0.8
Electrical	982	9.1	4.6
Instrumentation	113	1.0	0.5
Buildings	97	0.9	0.4
Subtotal	4,866	44.9	22.7
Services and miscellaneous	73	0.7	0.4
Subtotal excluding pond	4,939	45.6	23.1
Pond construction	5,888	54.4	27.5
Subtotal direct investment	10,827	100.0	50.6
Engineering design and supervision	791	7.3	3.7
Architect and engineering contractor	160	1.5	0.8
Construction expense	1,507	13.9	7.0
Contractor fees	587	5.4	2.7
Subtotal	13,872	128.1	64.8
Contingency	2,774	25.6	12.9
Subtotal fixed investment	16,646	153.7	77.7
Allowance for startup and modifications	1,076	9.9	5.0
Interest during construction	1,998	18.5	9.4
Subtotal capital investment	19,720	182.1	92.1
Land	1,147	10.6	5.4
Working capital	549	5.1	2.5
Total capital investment	21,416	197.8	100.0

a. Basis
Existing 500-MW plant (25-yr remaining life); 354.5 klb/hr (36% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 20.26 ft total depth, 328 acres.
Calcilox added at 7% of dry solids.

TABLE A-94. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 500-MW plant, 25-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	4,144 tons	48.00/ton	198,900	3.1
Calcilox	29,008 tons	58.00/ton	1,682,500	26.4
Subtotal raw materials cost			1,881,400	29.5
Conversion costs				
Operating labor and supervision	35,040 man-hr	12.50/man-hr	438,000	6.8
Maintenance				
Labor and materials				
4% of direct investment (plant)			197,600	3.1
3% of direct investment (pond)			176,600	2.8
Electricity	3,593 kkWh	0.029/kWh	104,200	1.6
Analyses	1,000 hr	17.00/man-hr	17,000	0.3
Subtotal conversion costs			933,400	14.6
Subtotal direct costs			2,814,800	44.1
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6.4% of total capital investment less land and working capital			1,262,100	19.8
Average cost of capital and taxes at 8.6% of total capital investment			1,841,800	28.9
Overhead				
Plant, 50% of conversion costs less utilities			414,500	6.5
Administrative, 10% of operating labor			43,800	0.7
Subtotal indirect costs			3,562,300	55.9
Total annual revenue requirements			6,377,100	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	14.23	7.12	1.82	

a. Basis

Remaining plant life, 25 yr.
Coal burned, 438,095 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment $21,416,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-95. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 500-MW plant, 20-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,275	25.2	12.5
Piping and insulation	262	2.9	1.4
Transport lines	657	7.3	3.6
Foundation and structural	313	3.5	1.7
Excavation, site preparation, roads and railroads	167	1.8	0.9
Electrical	982	10.9	5.4
Instrumentation	113	1.3	0.6
Buildings	97	1.1	0.6
Subtotal	4,866	54.0	26.8
Services and miscellaneous	73	0.8	0.4
Subtotal excluding pond	4,939	54.8	27.2
Pond construction	4,070	45.2	22.3
Subtotal direct investment	9,009	100.0	49.5
Engineering design and supervision	736	8.2	4.1
Architect and engineering contractor	155	1.7	0.8
Construction expense	1,358	15.0	7.5
Contractor fees	510	5.7	2.8
Subtotal	11,768	130.6	64.7
Contingency	2,354	26.2	13.0
Subtotal fixed investment	14,122	156.8	77.7
Allowance for startup and modifications	1,005	11.2	5.5
Interest during construction	1,695	18.7	9.3
Subtotal capital investment	16,822	186.7	92.5
Land	821	9.1	4.5
Working capital	538	6.0	3.0
Total capital investment	18,181	201.8	100.0

a. Basis

Existing 500-MW plant (20-yr remaining life); 354.5 klb/hr (36% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979.

Coal analysis (by wt): 3.5% S (dry basis), 16% ash.

Flyash removed with SO_2.

SO_2 and flyash removed to meet NSPS.

Limestone process with 1.5 stoichiometry based on SO_2 removed.

Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 17.82 ft total depth, 235 acres.

Calcilox added at 7% of dry solids.

TABLE A-96. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 500-MW plant, 20-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	4,144 tons	48.00/ton	198,900	3.4
Calcilox	29,008 tons	58.00/ton	1,682,500	28.3
Subtotal raw materials cost			1,881,400	31.7
Conversion costs				
Operating labor and supervision	35,040 man-hr	12.50/man-hr	438,000	7.4
Maintenance				
Labor and materials				
4% of direct investment (plant)			197,600	3.3
3% of direct investment (pond)			122,100	2.1
Electricity	3,593 kkWh	0.029/kWh	104,200	1.7
Analyses	1,000 hr	17.00/man-hr	17,000	0.3
Subtotal conversion costs			878,900	14.8
Subtotal direct costs			2,760,300	46.5
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.0% of total capital investment less land and working capital			1,177,500	19.8
Average cost of capital and taxes at 8.6% of total capital investment			1,572,200	26.5
Overhead				
Plant, 50% of conversion costs less utilities			387,400	6.5
Administrative, 10% of operating labor			43,800	0.7
Subtotal indirect costs			3,180,900	53.5
Total annual revenue requirements			5,941,200	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	13.26	6.63	1.70

a. Basis
Remaining plant life, 20 yr.
Coal burned, 438,095 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $18,281,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-97. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 500-MW plant, 15-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,275	30.0	14.7
Piping and insulation	262	3.5	1.7
Transport lines	657	8.7	4.2
Foundation and structural	313	4.1	2.0
Excavation, site preparation, roads and railroads	167	2.2	1.1
Electrical	982	12.9	6.3
Instrumentation	113	1.5	0.7
Buildings	97	1.3	0.6
Subtotal	4,866	64.2	31.3
Services and miscellaneous	73	1.0	0.4
Subtotal excluding pond	4,939	65.2	31.7
Pond construction	2,640	34.8	17.0
Subtotal direct investment	7,579	100.0	48.7
Engineering design and supervision	687	9.1	4.4
Architect and engineering contractor	150	2.0	1.0
Construction expense	1,232	16.2	7.9
Contractor fees	447	5.9	2.9
Subtotal	10,095	133.2	64.9
Contingency	2,019	26.6	13.0
Subtotal fixed investment	12,114	159.8	77.9
Allowance for startup and modifications	947	12.5	6.1
Interest during construction	1,454	19.2	9.3
Subtotal capital investment	14,515	191.5	93.3
Land	509	6.7	3.3
Working capital	529	7.0	3.4
Total capital investment	15,553	205.2	100.0

[a] Basis
Existing 500-MW plant (15-yr remaining life); 354.5 klb/hr (36% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 16.87 ft total depth, 145 acres.
Calcilox added at 7% of dry solids.

TABLE A-98. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 500-MW plant, 15-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	4,144 tons	48.00/ton	198,900	3.4
Calcilox	29,008 tons	58.00/ton	1,682,500	29.4
Subtotal raw materials cost			1,881,400	32.8
Conversion costs				
Operating labor and supervision	35,040 man-hr	12.50/man-hr	438,000	7.6
Maintenance				
Labor and materials				
4% of direct investment (plant)			197,600	3.5
3% of direct investment (pond)			79,200	1.4
Electricity	3,593 kkWh	0.029/kWh	104,200	1.8
Analyses	1,000 hr	17.00/man-hr	17,000	0.3
Subtotal conversion costs			836,000	14.6
Subtotal direct costs			2,117,400	47.4
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 8.7% of total capital investment less land and working capital			1,262,800	22.0
Average cost of capital and taxes at 8.6% of total capital investment			1,337,500	23.4
Overhead				
Plant, 50% of conversion costs less utilities			365,900	6.4
Administrative, 10% of operating labor			43,800	0.8
Subtotal indirect costs			3,010,100	52.6
Total annual revenue requirements			5,727,500	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	12.78	6.39	1.64	

a. Basis
Remaining plant life, 15 yr.
Coal burned, 438,095 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment $15,553,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-99. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: 1500-MW plant)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	4,363	17.0	9.1
Piping and insulation	424	1.7	0.9
Transport lines	978	3.8	2.0
Foundation and structural	540	2.1	1.1
Excavation, site preparation, roads and railroads	241	0.9	0.5
Electrical	1,301	5.1	2.7
Instrumentation	119	0.5	0.3
Buildings	115	0.5	0.2
Subtotal	8,081	31.6	16.8
Services and miscellaneous	121	0.5	0.2
Subtotal excluding pond	8,202	32.1	17.0
Pond construction	17,358	67.9	36.0
Subtotal direct investment	25,560	100.0	53.0
Engineering design and supervision	1,136	4.4	2.4
Architect and engineering contractor	207	0.8	0.4
Construction expense	2,823	11.1	5.9
Contractor fees	1,127	4.4	2.3
Subtotal	30,853	120.7	64.0
Contingency	6,171	24.2	12.8
Subtotal fixed investment	37,024	144.9	76.8
Allowance for startup and modifications	1,967	7.7	4.1
Interest during construction	4,443	17.3	9.2
Subtotal capital investment	43,434	169.9	90.1
Land	3,414	13.4	7.0
Working capital	1,387	5.4	2.9
Total capital investment	48,235	188.7	100.0

a. Basis

New 1500-MW plant (30-yr life); 1040 klb/hr (36% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 26.39 ft total depth, 975 acres.
Calcilox added at 7% of dry solids.

TABLE A-100. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 1500-MW plant)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	12,163 tons	48.00/ton	583,800	4.1
Calcilox	85,050 tons	58.00/ton	4,932,900	34.6
Subtotal raw materials cost			5,516,700	38.7
Conversion costs				
Operating labor and supervision			547,500	3.8
Maintenance				
Labor and materials				
4% of direct investment (plant)			328,100	2.3
3% of direct investment (pond)			520,700	3.6
Electricity	8,733 kkWh	0.027/kWh	235,800	1.7
Analyses	1,500 hr	17.00/hr	25,500	0.2
Subtotal conversion costs			1,657,600	11.6
Subtotal direct costs			7,174,300	50.3
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			2,606,000	18.3
Average cost of capital and taxes at 8.6% of total capital investment			3,718,200	26.0
Overhead				
Plant, 50% of conversion costs less utilities			710,900	5.0
Administrative, 10% of operating labor			54,800	0.4
Subtotal indirect costs			7,089,900	49.7
Total annual revenue requirements			14,264,200	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	10.87	5.44	1.36	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 1,285,714 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $48,235,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-101. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 1500-MW plant, 25-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	4,431	20.5	10.7
Piping and insulation	424	2.0	1.0
Transport lines	522	2.4	1.3
Foundation and structural	548	2.5	1.3
Excavation, site preparation, roads and railroads	243	1.1	0.6
Electrical	1,367	6.3	3.3
Instrumentation	119	0.6	0.3
Buildings	115	0.5	0.3
Subtotal	7,769	35.9	18.8
Services and miscellaneous	117	0.5	0.3
Subtotal excluding pond	7,886	36.4	19.1
Pond construction	13,758	63.6	33.2
Subtotal direct investment	21,644	100.0	52.3
Engineering design and supervision	1,051	4.9	2.5
Architect and engineering contractor	197	0.9	0.5
Construction expense	2,533	11.7	6.1
Contractor fees	993	4.6	2.4
Subtotal	26,418	122.1	63.8
Contingency	5,284	24.4	12.8
Subtotal fixed investment	31,702	146.5	76.6
Allowance for startup and modifications	1,794	8.3	4.3
Interest during construction	3,804	17.5	9.2
Subtotal capital investment	37,300	172.3	90.1
Land	2,697	12.5	6.5
Working capital	1,385	6.4	3.4
Total capital investment	41,382	191.2	100.0

a. Basis
Existing 1500-MW plant (25-yr remaining life); 1063 klb/hr (36% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 24.96 ft total depth, 770 acres.
Calcilox added at 7% of dry solids.

TABLE A-102. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 1500-MW plant, 25-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	12,432 tons	48.00/ton	596,700	4.3
Calcilox	86,800 tons	58.00/ton	5,034,400	36.4
Subtotal raw materials cost			5,631,100	40.7
Conversion costs				
Operating labor and supervision	43,800 man-hr	12.50/man-hr	547,500	4.0
Maintenance				
Labor and materials				
4% of direct investment (plant)			315,400	2.3
3% of direct investment (pond)			412,700	3.0
Electricity	8,775 kkWh	0.027/kWh	236,900	1.7
Analyses	1,500 hr	17.00/man-hr	25,500	0.2
Subtotal conversion costs			1,538,000	11.2
Subtotal direct costs			7,169,100	51.9
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6.4% of total capital investment less land and working capital			2,387,200	17.3
Average cost of capital and taxes at 8.6% of total capital investment			3,558,900	25.7
Overhead				
Plant, 50% of conversion costs less utilities			650,600	4.7
Administrative, 10% of operating labor			54,800	0.4
Subtotal indirect costs			6,651,500	48.1
Total annual revenue requirements			13,820,600	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	10.30	5.15	1.32

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a. Basis
Remaining plant life, 25 yr.
Coal burned, 1,314,286 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $41,382,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-103. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 1500-MW plant, 20-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	4,431	25.4	13.1
Piping and insulation	424	2.4	1.3
Transport lines	522	3.0	1.5
Foundation and structural	548	3.1	1.6
Excavation, site preparation, roads and railroads	243	1.4	0.7
Electrical	1,367	7.9	4.0
Instrumentation	119	0.7	0.4
Buildings	115	0.7	0.3
Subtotal	7,769	44.6	22.9
Services and miscellaneous	117	0.7	0.3
Subtotal excluding pond	7,886	45.3	23.2
Pond construction	9,514	54.6	28.1
Subtotal direct investment	17,400	100.0	51.3
Engineering design and supervision	954	5.5	2.8
Architect and engineering contractor	187	1.1	0.5
Construction expense	2,231	12.8	6.6
Contractor fees	842	4.8	2.5
Subtotal	21,614	124.2	63.7
Contingency	4,323	24.9	12.8
Subtotal fixed investment	25,937	149.1	76.5
Allowance for startup and modifications	1,642	9.4	4.8
Interest during construction	3,112	17.9	9.2
Subtotal capital investment	30,691	176.4	90.5
Land	1,874	10.8	5.5
Working capital	1,359	7.8	4.0
Total capital investment	33,924	195.0	100.0

a. Basis
Existing 1500-MW plant (20-yr remaining life); 1063 klb/hr (36% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 22.62 ft total depth, 535 acres.
Calcilox added at 7% of dry solids.

TABLE A-104. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 1500-MW plant, 20-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	12,432 tons	48.00/ton	596,700	4.7
Calcilox	86,800 tons	58.00/ton	5,034,400	39.5
Subtotal raw materials cost			5,631,100	44.2
Conversion costs				
Operating labor and supervision			547,500	4.3
Maintenance				
Labor and materials				
4% of direct investment (plant)			315,400	2.5
3% of direct investment (pond)			285,400	2.2
Electricity	8,775 kkWh	0.027/kWh	236,900	1.8
Analyses	1,500 hr	17.00/man-hr	25,500	0.2
Subtotal conversion costs			1,410,700	11.0
Subtotal direct costs			7,041,800	55.2
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.0% of total capital investment less land and working capital			2,148,400	16.9
Average cost of capital and taxes at 8.6% of total capital investment			2,917,500	22.9
Overhead				
Plant, 50% of conversion costs less utilities			586,900	4.6
Administrative, 10% of operating labor			54,800	0.4
Subtotal indirect costs			5,707,600	44.8
Total annual revenue requirements			12,749,400	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	9.50	4.75	1.21	

a. Basis
Remaining plant life, 20 yr.
Coal burned, 1,314,286 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $33,924,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-105. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 1500-MW plant, 15-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	4,431	31.7	15.8
Piping and insulation	424	3.0	1.5
Transport lines	522	3.7	1.9
Foundation and structural	548	3.9	2.0
Excavation, site preparation, roads and railroads	243	1.7	0.9
Electrical	1,367	9.8	4.9
Instrumentation	119	0.8	0.4
Buildings	115	0.8	0.4
Subtotal	7,769	55.4	27.8
Services and miscellaneous	117	0.9	0.4
Subtotal excluding pond	7,886	56.3	28.2
Pond construction	6,129	43.7	22.0
Subtotal direct investment	14,015	100.0	50.2
Engineering design and supervision	866	6.2	3.1
Architect and engineering contractor	178	1.3	0.6
Construction expense	1,973	14.0	7.1
Contractor fees	714	5.1	2.6
Subtotal	17,746	126.6	63.6
Contingency	3,549	25.3	12.7
Subtotal fixed investment	21,295	151.9	76.3
Allowance for startup and modifications	1,517	10.8	5.4
Interest during construction	2,555	18.3	9.2
Subtotal capital investment	25,367	181.0	90.9
Land	1,199	8.6	4.3
Working capital	1,339	9.5	4.8
Total capital investment	27,905	199.1	100.0

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a. Basis

Existing 1500-MW plant (15-yr remaining life); 1063 klb/hr (36% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979.

Coal analysis (by wt): 3.5% S (dry basis), 16% ash.

Flyash removed with SO_2.

SO_2 and flyash removed to meet NSPS.

Limestone process with 1.5 stoichiometry based on SO_2 removed.

Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 20.40 ft total depth, 343 acres.

Calcilox added at 7% of dry solids.

TABLE A-106. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 1500-MW plant, 15-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	12,432 tons	48.00/ton	596,700	4.9
Calcilox	86,800 tons	58.00/ton	5,034.400	41.5
Subtotal raw materials cost			5,631,100	46.4
Conversion costs				
Operating labor and supervision	43,800 man-hr	12.50/man-hr	547,500	4.5
Maintenance				
Labor and materials				
4% of direct investment (plant)			315,400	2.6
3% of direct investment (pond)			183,900	1.5
Electricity	8,775 kkWh	0.027/kWh	235,900	2.0
Analyses	1,500 hr	17.00/man-hr	25,500	0.2
Subtotal conversion costs			1,309,200	10.8
Subtotal direct costs			6,940,300	57.2
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 8.7% of total capital investment less land and working capital			2,206,900	18.2
Average cost of capital and taxes at 8.6% of total capital investment			2,399,800	19.8
Overhead				
Plant, 50% of conversion costs less utilities			536,200	4.4
Administrative, 10% of operating labor			54,800	0.4
Subtotal indirect costs			5,197,700	42.8
Total annual revenue requirements			12,138,000	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	9.04	4.52	1.16

a. Basis
Remaining plant life, 15 yr.
Coal burned, 1,314,286 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $27,105,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-107. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: 12% ash in coal)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,066	18.9	9.6
Piping and insulation	217	2.0	1.0
Transport lines	487	4.5	2.3
Foundation and structural	290	2.7	1.4
Excavation, site preparation, roads and railroads	156	1.4	0.7
Electrical	965	8.9	4.5
Instrumentation	113	1.0	0.5
Buildings	115	1.1	0.6
Subtotal	4,409	40.5	20.6
Services and miscellaneous	66	0.7	0.3
Subtotal excluding pond	4,475	41.2	20.9
Pond construction	6,398	58.8	29.8
Subtotal direct investment	10,873	100.0	50.7
Engineering design and supervision	805	7.4	3.7
Architect and engineering contractor	162	1.5	0.8
Construction expense	1,474	13.6	6.9
Contractor fees	589	5.4	2.7
Subtotal	13,903	127.9	64.8
Contingency	2,781	25.5	13.0
Subtotal fixed investment	16,684	153.4	77.8
Allowance for startup and modifications	1,029	9.5	4.8
Interest during construction	2,002	18.4	9.3
Subtotal capital investment	19,715	181.3	91.9
Land	1,253	11.5	5.9
Working capital	478	4.4	2.2
Total capital investment	21,446	197.2	100.0

a. Basis
New 500-MW plant (30-yr life); 286 klb/hr (36% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 12% ash, 11,100 Btu/lb HV.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 20.59 ft total depth, 358 acres.
Calcilox added at 7% of dry solids.

TABLE A-108. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 12% ash in coal)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	3,350 tons	48.00/ton	160,800	2.7
Calcilox	23,443 tons	58.00/ton	1,359,700	23.0
Subtotal raw materials cost			1,520,500	25.7
Conversion costs				
Operating labor and supervision	35,040 man-hr	12.50/man-hr	438,000	7.4
Maintenance				
Labor and materials				
4% of direct investment (plant)			179,000	3.0
3% of direct investment (pond)			191,900	3.2
Electricity	3,235 kkWh	0.029/kWh	93,800	1.6
Analyses	1,000 hr	17.00/man-hr	17,000	0.3
Subtotal conversion costs			919,700	15.5
Subtotal direct costs			2,440,200	41.2
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,182,900	20.0
Average cost of capital and taxes at 8.6% of total capital investment			1,842,400	31.1
Overhead				
Plant, 50% of conversion costs less utilities			413,000	7.0
Administrative, 10% of operating labor			43,800	0.7
Subtotal indirect costs			3,482,100	58.8
Total annual revenue requirements			5,922,300	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	16.43	8.22	1.69	

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a. Basis
Remaining plant life, 30 yr.
Coal burned, 405,405 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $21,446,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-109. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: 20% ash in coal)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,519	18.8	9.6
Piping and insulation	272	2.0	1.0
Transport lines	697	5.2	2.7
Foundation and structural	382	2.9	1.5
Excavation, site preparation, roads and railroads	172	1.3	0.7
Electrical	1,092	8.2	4.2
Instrumentation	119	0.9	0.5
Buildings	115	0.9	0.4
Subtotal	5,368	40.2	20.6
Services and miscellaneous	81	0.6	0.3
Subtotal excluding pond	5,449	40.8	20.9
Pond construction	7,905	59.2	30.4
Subtotal direct investment	13,354	100.0	51.3
Engineering design and supervision	868	6.5	3.3
Architect and engineering contractor	171	1.3	0.7
Construction expense	1,744	13.0	6.7
Contractor fees	688	5.2	2.7
Subtotal	16,825	126.0	64.7
Contingency	3,365	25.2	12.9
Subtotal fixed investment	20,190	151.2	77.6
Allowance for startup and modifications	1,229	9.2	4.7
Interest during construction	2,423	18.1	9.3
Subtotal capital investment	23,842	178.5	91.6
Land	1,556	11.7	6.0
Working capital	630	4.7	2.4
Total capital investment	26,028	194.9	100.0

a. Basis

New 500-MW plant (30-yr life); 414 klb/hr (36% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 20% ash, 9,900 Btu/lb HV.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 21.60 ft total depth, 445 acres.
Calcilox added at 7% of dry solids.

TABLE A-110. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 20% ash in coal)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	4,844 tons	48.00/ton	232,500	3.1
Calcilox	33,908 tons	58.00/ton	1,966,700	26.6
Subtotal raw materials cost			2,199,200	29.7
Conversion costs				
Operating labor and supervision	35,040 man-hr	12.50/man-hr	438,000	5.9
Maintenance				
Labor and materials				
4% of direct investment (plant)			218,000	3.0
3% of direct investment (pond)			237,200	3.2
Electricity	4,435 kkWh	0.029/kWh	128,500	1.7
Analyses	1,000 hr	17.00/man-hr	17,000	0.2
Subtotal conversion costs			1,038,700	14.0
Subtotal direct costs			3,237,900	43.7
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,430,500	19.3
Average cost of capital and taxes at 8.6% of total capital investment			2,238,400	30.2
Overhead				
Plant, 50% of conversion costs less utilities			455,100	6.2
Administrative, 10% of operating labor			43,800	0.6
Subtotal indirect costs			4,167,800	56.3
Total annual revenue requirements			7,405,700	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	15.58	7.79	2.12

a. Basis
Remaining plant life, 30 yr.
Coal burned, 454,545 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $26,028,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-111. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: 2% S in coal)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	1,865	19.2	9.7
Piping and insulation	215	2.2	1.1
Transport lines	487	5.0	2.5
Foundation and structural	230	2.4	1.2
Excavation, site preparation, roads and railroads	153	1.6	0.8
Electrical	862	8.9	4.5
Instrumentation	102	1.1	0.5
Buildings	115	1.2	0.6
Subtotal	4,029	41.6	20.9
Services and miscellaneous	60	0.6	0.4
Subtotal excluding pond	4,089	42.2	21.3
Pond construction	5,605	57.8	29.1
Subtotal direct investment	9,694	100.0	50.4
Engineering design and supervision	759	7.8	3.9
Architect and engineering contractor	154	1.6	0.8
Construction expense	1,348	13.9	7.0
Contractor fees	540	5.6	2.8
Subtotal	12,495	128.9	64.9
Contingency	2,499	25.8	13.0
Subtotal fixed investment	14,994	154.7	77.9
Allowance for startup and modifications	939	9.7	4.9
Interest during construction	1,799	18.5	9.3
Subtotal capital investment	17,732	182.9	92.1
Land	1,096	11.3	5.7
Working capital	423	4.4	2.2
Total capital investment	19,251	198.6	100.0

a. Basis

New 500-MW plant (30-yr life); 241 klb/hr (36% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 2% S (dry basis), 16% ash, 10,700 Btu/lb HV.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 19.95 ft total depth, 313 acres.
Calcilox added at 7% of dry solids.

TABLE A-112. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 2% S in coal)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	2,818 tons	48.00/ton	135,300	2.6
Calcilox	19,730 tons	58.00/ton	1,144,300	21.5
Subtotal raw materials cost			1,279,600	24.1
Conversion costs				
Operating labor and supervision	35,040 man-hr	12.50/man-hr	438,000	8.2
Maintenance				
Labor and materials				
4% of direct investment (plant)			163,600	3.1
3% of direct investment (pond)			168,100	3.2
Electricity	3,137 kkWh	0.029/kWh	91,000	1.7
Analyses	1,000 hr	17.00/man-hr	17,000	0.3
Subtotal conversion costs			877,700	16.5
Subtotal direct costs			2,157,300	40.6
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,063,900	20.0
Average cost of capital and taxes at 8.6% of total capital investment			1,655,600	31.2
Overhead				
Plant, 50% of conversion costs less utilities			393,400	7.4
Administrative, 10% of operating labor			43,800	0.8
Subtotal indirect costs			3,156,700	59.4
Total annual revenue requirements			5,314,000	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	17.45	8.73	1.52	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 470,561 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $19,251,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-113. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: 5% S in coal)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,652	18.1	9.4
Piping and insulation	273	1.9	1.0
Transport lines	657	4.5	2.3
Foundation and structural	402	2.7	1.4
Excavation, site preparation, roads and railroads	176	1.2	0.6
Electrical	1,089	7.4	3.8
Instrumentation	119	0.8	0.4
Buildings	115	0.8	0.4
Subtotal	5,483	37.4	19.3
Services and miscellaneous	84	0.6	0.3
Subtotal excluding pond	5,567	38.0	19.6
Pond construction	9,073	62.0	31.9
Subtotal direct investment	14,640	100.0	51.5
Engineering design and supervision	897	6.1	3.2
Architect and engineering contractor	174	1.2	0.6
Construction expense	1,866	12.7	6.5
Contractor fees	742	5.0	2.6
Subtotal	18,319	125.0	64.4
Contingency	3,684	25.0	13.0
Subtotal fixed investment	22,003	150.3	77.4
Allowance for startup and modifications	1,303	8.9	4.6
Interest during construction	2,652	18.1	9.3
Subtotal capital investment	25,958	177.3	91.3
Land	1,790	12.2	6.3
Working capital	675	4.6	2.4
Total capital investment	28,423	194.1	100.0

[a] Basis

New 500-MW plant (30-yr life); 450.9 klb/hr (36% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 5% S (dry basis), 16% ash, 10,400 Btu/lb HV.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities.
50% solids settled density, 22.31 ft total depth, 511 acres.
Calcilox added at 7% of dry solids.

TABLE A-114. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 5% S in coal)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	5,271 tons	48.00/ton	253,000	3.2
Calcilox	36,750	58.00/ton	2,131,500	26.6
Subtotal raw materials cost			2,384,500	29.8
Conversion costs				
Operating labor and supervision	35,040 man-hr	12.50/man-hr	438,000	5.5
Maintenance				
Labor and materials				
4% of direct investment (plant)			226,700	2.8
3% of direct investment (pond)			272,200	3.4
Electricity	4,515 kkWh	0.029/kWh	130,900	1.6
Analyses	1,000 hr	17.00/man-hr	17,000	0.2
Subtotal conversion costs			1,084,800	13.5
Subtotal direct costs			3,469,300	43.3
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,563,500	19.5
Average cost of capital and taxes at 8.6% of total capital investment			2,453,000	30.6
Overhead				
Plant, 50% of conversion costs less utilities			477,000	6.0
Administrative, 10% of operating labor			43,800	0.6
Subtotal indirect costs			4,537,300	56.7
Total annual revenue requirements			8,006,600	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	14.08	7.04	2.29	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 432,692 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $28,523,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-115. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: no flyash, 200-MW plant)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	1,033	17.4	8.4
Piping and insulation	162	2.7	1.3
Transport lines	326	5.5	2.7
Foundation and structural	130	2.2	1.1
Excavation, site preparation, roads and railroads	132	2.2	1.1
Electrical	787	1.3	6.4
Instrumentation	99	1.7	0.8
Buildings	115	1.9	0.9
Subtotal	2,784	46.9	22.7
Services and miscellaneous	42	0.7	0.4
Subtotal excluding pond	2,826	47.6	23.1
Pond construction	3,105	52.4	25.4
Subtotal direct investment	5,931	100.0	48.5
Engineering design and supervision	658	11.1	5.4
Architect and engineering contractor	140	2.4	1.1
Construction expense	925	15.5	7.6
Contractor fees	371	6.3	3.0
Subtotal	8,025	135.3	65.6
Contingency	1,605	27.1	13.1
Subtotal fixed investment	9,630	162.4	78.7
Allowance for startup and modifications	653	11.0	5.3
Interest during construction	1,156	19.5	9.4
Subtotal capital investment	11,439	192.9	93.4
Land	602	10.1	4.9
Working capital	201	3.4	1.7
Total capital investment	12,242	206.4	100.0

a. Basis

New 200-MW plant (30-yr life); 75 klb/hr (36% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed independently of SO_2 and sludge contains no flyash.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 17.43 ft total depth, 172 acres.
Calcilox added at 7% of dry solids.

TABLE A-116. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 200-MW plant, no flyash)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	879 tons	48.00/ton	42,200	1.4
Calcilox	6,153 tons	58.00/ton	356,900	11.6
Subtotal raw materials cost			399,100	13.0
Conversion costs				
Operating labor and supervision	26,280 man-hr	12.50/man-hr	328,500	10.7
Maintenance				
Labor and materials				
4% of direct investment (plant)			113,000	3.7
3% of direct investment (pond)			93,200	3.0
Electricity	2,078 kkWh	0.031/kWh	64,400	2.1
Analyses	1,000 hr	17.00/man-hr	17,000	0.6
Subtotal conversion costs			616,100	20.1
Subtotal direct costs			1,015,200	33.1
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			686,300	22.4
Average cost of capital and taxes at 8.6% of total capital investment			1,052,800	34.4
Overhead				
Plant, 50% of conversion costs less utilities			275,900	9.0
Administrative, 10% of operating labor			32,900	1.1
Subtotal indirect costs			2,047,900	66.9
Total annual revenue requirements			3,063,100	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	25.74	12.87	2.19

a. Basis
Remaining plant life, 30 yr.
Coal burned, 175,238 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $12,242,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-117. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: no flyash)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	1,668	16.7	8.5
Piping and insulation	203	2.0	1.0
Transport lines	451	4.5	2.3
Foundation and structural	212	2.1	1.1
Excavation, site preparation, roads and railroads	143	1.4	0.7
Electrical	888	8.9	4.5
Instrumentation	103	1.0	0.5
Buildings	115	1.2	0.6
Subtotal	3,783	37.8	19.2
Services and miscellaneous	57	0.6	0.3
Subtotal excluding pond	3,840	38.4	19.5
Pond construction	6,161	61.6	31.2
Subtotal direct investment	10,001	100.0	50.7
Engineering design and supervision	775	7.7	3.9
Architect and engineering contractor	155	1.5	0.8
Construction expense	1,352	13.6	6.8
Contractor fees	552	5.5	2.8
Subtotal	12,835	128.3	65.0
Contingency	2,567	25.7	13.0
Subtotal fixed investment	15,402	154.0	78.0
Allowance for startup and modifications	924	9.2	4.7
Interest during construction	1,848	18.5	9.3
Subtotal capital investment	18,174	181.7	92.0
Land	1,207	12.1	6.1
Working capital	364	3.6	1.9
Total capital investment	19,745	197.4	100.0

a. Basis
New 500-MW plant (30-yr life); 184 klb/hr (36% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 15% ash.
Flyash removed independently of SO_2 and sludge contains no flyash.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 20.40 ft total depth, 345 acres.
Calcilox added at 7% of dry solids.

TABLE A-118. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: separate system for disposal/removal of flyash)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	2,149 tons	48.00/ton	103,200	2.0
Calcilox	15,050 tons	58.00/ton	872,900	17.2
Subtotal raw materials cost			976,100	19.2
Conversion costs				
Operating labor and supervision	35,040 man-hr	12.50/man-hr	438,000	8.7
Maintenance				
Labor and materials				
4% of direct investment (plant)			153,600	3.0
3% of direct investment (pond)			184,800	3.6
Electricity	2,569 kkWh	0.029/kWh	74,500	1.5
Analyses	1,000 hr	17.00/man-hr	17,000	0.3
Subtotal conversion costs			867,900	17.1
Subtotal direct costs			1,844,000	36.3
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,090,400	21.5
Average cost of capital and taxes at 8.6% of total capital investment			1,698,100	33.5
Overhead				
Plant, 50% of conversion costs less utilities			396,700	7.8
Administrative, 10% of operating labor			43,800	0.9
Subtotal indirect costs			3,229,000	63.7
Total annual revenue requirements			5,073,000	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	17.48	8.74	1.45	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $19,745,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-119. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: no flyash, 1500-MW plant)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,989	14.6	7.7
Piping and insulation	291	1.4	0.8
Transport lines	779	3.8	2.0
Foundation and structural	342	1.7	0.9
Excavation, site preparation, roads and railroads	189	0.9	0.5
Electrical	1,131	5.5	2.9
Instrumentation	119	0.6	0.3
Buildings	115	0.6	0.3
Subtotal	5,955	29.1	15.4
Services and miscellaneous	89	0.5	0.2
Subtotal excluding pond	6,044	29.6	15.6
Pond construction	14,394	70.4	37.2
Subtotal direct investment	20,438	100.0	52.8
Engineering design and supervision	1,030	5.0	2.6
Architect and engineering contractor	189	0.9	0.5
Construction expense	2,302	11.3	5.9
Contractor fees	951	4.7	2.5
Subtotal	24,910	121.9	64.3
Contingency	4,982	24.4	12.9
Subtotal fixed investment	29,892	146.3	77.2
Allowance for startup and modifications	1,550	7.6	4.0
Interest during construction	3,587	17.5	9.3
Subtotal capital investment	35,029	171.4	90.5
Land	2,849	14.0	7.3
Working capital	844	4.1	2.2
Total capital investment	38,722	189.5	100.0

a. Basis
New 1500-MW plant (30-yr life); 551.6 klb/hr (36% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed independently of SO_2 and sludge contains no flyash.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 25.00 ft total depth, 814 acres.
Calcilox added at 7% of dry solids.

TABLE A-120. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 1500-MW plant, separate system for disposal/removal of flyash)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	6,451 tons	48.00/ton	309,600	3.0
Calcilox	45,150 tons	58.00/ton	2,618,700	25.0
Subtotal raw materials cost			2,928,300	28.0
Conversion costs				
Operating labor and supervision	43,800 man-hr	12.50/man-hr	547,500	5.3
Maintenance				
Labor and materials				
4% of direct investment (plant)			241,800	2.3
3% of direct investment (pond)			431,800	4.1
Electricity	6,034 kkWh	0.027/kWh	162,900	1.6
Analyses	,500 hr	17.00/man-hr	25,500	0.2
Subtotal conversion costs			1,409,500	13.5
Subtotal direct costs			4,337,800	41.5
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			2,101,700	20.1
Average cost of capital and taxes at 8.6% of total capital investment			3,330,100	31.9
Overhead				
Plant, 50% of conversion costs less utilities			623,300	6.0
Administrative, 10% of operating labor			54,800	0.5
Subtotal indirect costs			6,109,900	58.5
Total annual revenue requirements			10,447,700	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	12.01	6.01	1.00

a. Basis
Remaining plant life, 30 yr.
Coal burned, 1,285,714 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $38,722,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-121. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: disposal pond 5 mi from scrubber facilities)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,955	18.3	9.5
Piping and insulation	246	1.5	0.8
Transport lines	3,484	21.5	11.2
Foundation and structural	315	2.0	1.0
Excavation, site preparation, roads and railroads	337	2.1	1.1
Electrical	1,073	6.6	3.5
Instrumentation	112	0.7	0.4
Buildings	115	0.7	0.4
Subtotal	8,637	53.4	27.9
Services and miscellaneous	130	0.8	0.4
Subtotal excluding pond	8,767	54.2	28.3
Pond construction	7,410	45.8	23.9
Subtotal direct investment	16,177	100.0	52.2
Engineering design and supervision	913	5.6	2.9
Architect and engineering contractor	185	1.1	0.6
Construction expense	2,201	13.7	7.1
Contractor fees	796	4.9	2.6
Subtotal	20,272	125.3	65.4
Contingency	4,054	25.1	13.1
Subtotal fixed investment	24,326	150.4	78.5
Allowance for startup and modifications	1,692	10.5	5.5
Interest during construction	2,919	18.0	9.4
Subtotal capital investment	28,937	178.9	93.4
Land	1,450	9.0	4.6
Working capital	607	3.7	2.0
Total capital investment	30,994	191.6	100.0

[a] Basis
New 500-MW plant (30-yr life); 347 klb/hr (36% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 5 mi from scrubber facilities, 50% solids settled density, 21.38 ft total depth, 414 acres.
Calcilox added at 7% of dry solids.

TABLE A-122. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: disposal area 5 mi from scrubber facilities)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	4,053 tons	48.00/ton	194,500	2.4
Calcilox	28,378 tons	58.00/ton	1,645,900	20.3
Subtotal raw materials cost			1,840,400	22.7
Conversion costs				
Operating labor and supervision	35,040 man-hr	12.50/man-hr	438,000	5.5
Maintenance				
Labor and materials				
4% of direct investment (plant)			350,700	4.3
3% of direct investment (pond)			222,300	2.7
Electricity	10,200 kkWh	0.029/kWh	295,800	3.6
Analyses	1,000 hr	17.00/man-hr	17,000	0.2
Subtotal conversion costs			1,323,800	16.3
Subtotal direct costs			3,164,200	39.0
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,736,200	21.4
Average cost of capital and taxes at 8.6% of total capital investment			2,665,500	32.8
Overhead				
Plant, 50% of conversion costs less utilities			514,000	6.3
Administrative, 10% of operating labor			43,800	0.5
Subtotal indirect costs			4,959,500	61.0
Total annual revenue requirements			8,123,700	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	18.57	9.29	2.32

a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $30,994,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-123. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: disposal pond 10 mi from scrubber facilities)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,982	14.9	7.9
Piping and insulation	246	1.2	0.6
Transport lines	6,969	34.9	18.5
Foundation and structural	315	1.6	0.8
Excavation, site preparation, roads and railroads	516	2.6	1.4
Electrical	1,108	5.5	2.9
Instrumentation	112	0.6	0.3
Buildings	115	0.6	0.3
Subtotal	12,363	61.9	32.7
Services and miscellaneous	185	1.0	0.5
Subtotal excluding pond	12,548	62.9	33.2
Pond construction	7,410	37.1	19.6
Subtotal direct investment	19,958	100.0	52.8
Engineering design and supervision	1,039	5.2	2.8
Architect and engineering contractor	216	1.1	0.6
Construction expense	2,726	13.6	7.2
Contractor fees	934	4.7	2.5
Subtotal	24,873	124.6	65.9
Contingency	4,975	25.0	13.1
Subtotal fixed investment	29,848	149.6	79.0
Allowance for startup and modifications	2,244	11.2	6.0
Interest during construction	3,582	17.9	9.5
Subtotal capital investment	35,674	178.7	94.5
Land	1,450	7.3	3.8
Working capital	641	3.2	1.7
Total capital investment	37,765	189.2	100.0

a. Basis

New 500-MW plant (30-yr life); 347 klb/hr (36% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 10 mi from scrubber facilities, 50% solids settled density, 21.38 ft total depth, 414 acres.
Calcilox added at 7% of dry solids.

TABLE A-124. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: disposal area 10 mi from scrubber facilities)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	4,053 tons	48.00/ton	194,500	2.1
Calcilox	28,378 tons	58.00/ton	1,645,900	17.6
Subtotal raw materials cost			1,840,400	19.7
Conversion costs				
Operating labor and supervision	35,040 man-hr	12.50/man-hr	438,000	4.6
Maintenance				
Labor and materials				
4% of direct investment (plant)			501,900	5.4
3% of direct investment (pond)			222,300	2.4
Electricity	11,000 kkWh	0.029/kWh	319,000	3.4
Analyses	1,000 hr	17.00/man-hr	17,000	0.2
Subtotal conversion costs			1,418,200	16.0
Subtotal direct costs			3,338,600	35.7
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			2,140,400	22.8
Average cost of capital and taxes at 8.6% of total capital investment			3,247,800	34.7
Overhead				
Plant, 50% of conversion costs less utilities			589,600	6.3
Administrative, 10% of operating labor			43,800	0.5
Subtotal indirect costs			6,021,600	64.3
Total annual revenue requirements			9,360,200	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	21.39	10.70	2.67	

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a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $37,765,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-125. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: Calcilox added at 5%)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,208	18.6	9.6
Piping and insulation	262	2.2	1.1
Transport lines	657	5.5	2.8
Foundation and structural	234	2.0	1.0
Excavation, site preparation, roads and railroads	161	1.4	0.7
Electrical	754	6.4	3.3
Instrumentation	110	0.9	0.5
Buildings	97	0.8	0.4
Subtotal	4,483	37.8	19.4
Services and miscellaneous	67	0.6	0.3
Subtotal excluding pond	4,550	38.4	19.7
Pond construction	7,312	61.6	31.6
Subtotal direct investment	11,862	100.0	51.3
Engineering design and supervision	806	6.8	3.5
Architect and engineering contractor	158	1.3	0.7
Construction expense	1,557	13.2	6.7
Contractor fees	629	5.3	2.7
Subtotal	15,012	126.6	64.9
Contingency	3,002	25.3	13.0
Subtotal fixed investment	18,014	151.9	77.9
Allowance for startup and modifications	1,070	9.0	4.6
Interest during construction	2,162	18.2	9.4
Subtotal capital investment	21,246	179.1	91.9
Land	1,420	12.0	6.1
Working capital	454	3.8	2.0
Total capital investment	23,120	194.9	100.0

a. Basis
New 500-MW plant (30-yr life); 344 klb/hr (36% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 21.42 ft total depth, 406 acres.
Calcilox added at 5% of dry solids.

TABLE A-126. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 5% Calcilox added to dry solids)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	4,053 tons	48.00/ton	194,500	3.2
Calcilox	20,269 tons	58.00/ton	1,175,600	19.5
Subtotal raw materials cost			1,370,100	22.7
Conversion costs				
Operating labor and supervision	35,040 man-hr	12.50/man-hr	438,000	7.2
Maintenance				
Labor and materials				
4% of direct investment (plant)			182,000	3.0
3% of direct investment (pond)			219,400	3.6
Electricity	3,102 kkWh	0.029/kWh	90,000	1.5
Analyses	1,000 hr	17.00/man-hr	17,000	0.3
Subtotal conversion costs			946,400	15.6
Subtotal direct costs			2,316,500	38.3
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,274,800	21.1
Average cost of capital and taxes at 8.6% of total capital investment			1,988,300	32.8
Overhead				
Plant, 50% of conversion costs less utilities			428,200	7.1
Administrative, 10% of operating labor			43,800	0.7
Subtotal indirect costs			3,735,100	61.7
Total annual revenue requirements			6,051,600	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	14.05	7.05	1.73

a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $23,120,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-127. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: Calcilox added at 10%)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,379	18.5	9.4
Piping and insulation	262	2.1	1.0
Transport lines	657	5.1	2.6
Foundation and structural	397	3.1	1.6
Excavation, site preparation, roads and railroads	169	1.3	0.7
Electrical	1,118	8.7	4.4
Instrumentation	119	0.9	0.5
Buildings	115	0.9	0.5
Subtotal	5,216	40.6	20.7
Services and miscellaneous	78	0.6	0.3
Subtotal excluding pond	5,294	41.6	21.0
Pond construction	7,564	58.4	30.0
Subtotal direct investment	12,858	100.0	51.0
Engineering design and supervision	859	6.7	3.4
Architect and engineering contractor	171	1.3	0.7
Construction expense	1,694	13.2	6.7
Contractor fees	669	5.2	2.7
Subtotal	16,251	126.4	64.5
Contingency	3,250	25.3	12.9
Subtotal fixed investment	19,501	151.7	77.4
Allowance for startup and modifications	1,194	9.3	4.7
Interest during construction	2,340	18.2	9.3
Subtotal capital investment	23,035	179.1	91.4
Land	1,485	11.6	5.9
Working capital	689	5.4	2.7
Total capital investment	25,209	196.1	100.0

a. Basis
New 500-MW plant (30-yr life); 350 klb/hr (36% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 21.48 ft total depth, 424 acres.
Calcilox added at 10% of dry solids.

TABLE A-128. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 10% Calcilox added to dry solids)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	4,053 tons	48.00/ton	194,500	2.6
Calcilox	40,400 tons	58.00/ton	2,354,800	31.1
Subtotal raw materials cost			2,549,300	33.7
Conversion costs				
Operating labor and supervision	35,040 man-hr	12.50/man-hr	438,000	5.8
Maintenance				
Labor and materials				
4% of direct investment (plant)			211,800	2.8
3% of direct investment (pond)			226,900	3.0
Electricity	3,200 kkWh	0.029/kWh	92,800	1.2
Analyses	1,000 hr	17.00/man-hr	17,000	0.2
Subtotal conversion costs			986,500	13.0
Subtotal direct costs			3,535,800	46.7
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,382,100	18.2
Average cost of capital and taxes at 8.6% of total capital investment			2,168,000	28.6
Overhead				
Plant, 50% of conversion costs less utilities			446,900	5.9
Administrative, 10% of operating labor			43,800	0.6
Subtotal indirect costs			4,040,800	53.3
Total annual revenue requirements			7,576,600	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	16.85	8.43	2.16

a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $25,209,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-129. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: lime process with 1.1 stoichiometry based on SO_2 removed)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	1,933	17.6	9.1
Piping and insulation	230	2.1	1.1
Transport lines	657	6.0	3.1
Foundation and structural	262	2.4	1.2
Excavation, site preparation, roads and railroads	165	1.5	0.8
Electrical	800	7.3	3.8
Instrumentation	90	0.8	0.4
Buildings	115	1.0	0.5
Subtotal	4,252	38.7	20.0
Services and miscellaneous	64	0.6	0.3
Subtotal excluding pond	4,316	39.3	20.3
Pond construction	6,669	60.7	31.2
Subtotal direct investment	10,985	100.0	51.5
Engineering design and supervision	605	5.5	2.9
Architect and engineering contractor	111	1.0	0.5
Construction expense	1,469	13.4	6.9
Contractor fees	593	5.4	2.8
Subtotal	13,763	125.3	64.6
Contingency	2,753	25.1	12.9
Subtotal fixed investment	16,516	150.4	77.5
Allowance for startup and modifications	985	9.0	4.6
Interest during construction	1,982	18.0	9.3
Subtotal capital investment	19,483	177.4	91.4
Land	1,306	11.9	6.1
Working capital	529	4.8	2.5
Total capital investment	21,318	194.1	100.0

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a. Basis

New 500-MW plant (30-yr life); 301.8 klb/hr (36% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Lime process with 1.1 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, 20.80 ft total depth, 373 acres.
Calcilox added at 7% of dry solids.
Scrubber system underflow 10% solids (all other cases 15%).

TABLE A-130. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: lime process with 1.1 stoichiometry)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	3,528 tons	48.00/ton	169,300	2.7
Calcilox	27,703 tons	58.00/ton	1,606,800	26.1
Subtotal raw materials cost			1,776,100	28.8
Conversion costs				
Operating labor and supervision	35,040 man-hr	12.50/man-hr	438,000	7.1
Maintenance				
Labor and materials				
4% of direct investment (plant)			172,600	2.8
3% of direct investment (pond)			200,100	3.2
Electricity	3,600 kkWh	0.029/kWh	104,400	1.7
Analyses	1,000 hr	17.00/man-hr	17,000	0.3
Subtotal conversion costs			932,100	15.1
Subtotal direct costs			2,708,200	43.9
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,169,000	19.0
Average cost of capital and taxes at 8.6% of total capital investment			1,833,300	29.7
Overhead				
Plant, 50% of conversion costs less utilities			413,900	6.7
Administrative, 10% of operating labor			43,800	0.7
Subtotal indirect costs			3,460,000	56.1
Total annual revenue requirements			6,168,200	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	8.10	4.05	1.76	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 25,894 lb/hr, 10,166 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $21,318,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-131. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: intermediate ponding and truck to landfill for disposal)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,272	40.7	17.9
Piping and insulation	262	4.7	2.1
Transport lines	-	-	-
Foundation and structural	313	5.6	2.5
Excavation, site preparation, roads and railroads	714	12.8	5.6
Electrical	974	17.5	7.7
Instrumentation	113	2.0	0.9
Buildings	115	2.1	0.9
Subtotal	4,763	85.4	37.6
Services and miscellaneous	71	1.3	0.6
Subtotal excluding trucks and equipment	4,834	86.7	38.2
Trucks and earthmoving equipment	739	13.3	5.8
Subtotal direct investment	5,573	100.0	44.0
Engineering design and supervision	530	9.5	4.2
Architect and engineering contractor	133	2.4	1.0
Construction expense	925	16.5	7.3
Contractor fees	354	6.4	2.8
Subtotal	7,515	134.8	59.3
Contingency	1,503	27.0	11.9
Subtotal fixed investment	9,018	161.8	71.2
Allowance for startup and modifications	828	14.9	6.5
Interest during construction	1,082	19.4	8.5
Subtotal capital investment	10,928	196.1	86.2
Land	1,007	18.1	8.0
Working capital	735	13.2	5.8
Total capital investment	12,670	227.4	100.0

[a] Basis
New 500-MW plant (30-yr life); 347 klb/hr (36% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Landfill acreage 271 acres, 30 ft depth; intermediate ponding and disposal of 50% solids sludge, 1 mi from scrubber facilities.
Calcilox added at 7% of dry solids.

TABLE A-132. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: intermediate ponding, transport by truck)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	4,053 tons	48.00/ton	194,500	2.9
Calcilox	28,378 tons	58.00/ton	1,645,900	24.9
Subtotal raw materials cost			1,840,400	27.8
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	6.6
Solids disposal equipment	52,560 man-hr	17.00/man-hr	893,500	13.4
Maintenance--plant labor and material, 4% of direct investment			222,900	3.4
Landfill operation				
Land preparation			11,000	0.2
Trucks (fuel and maintenance)	677,000 tons	0.06/ton	40,600	0.6
Earthmoving equipment (fuel and maintenance)	677,000 tons	0.16/ton	108,300	1.6
Electricity	3,577 kkWh	0.029/kWh	103,700	1.6
Analyses	1,000 hr	17.00/man-hr	17,000	0.3
Subtotal conversion costs			1,835,000	27.7
Subtotal direct costs			3,675,400	55.5
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.8% of total capital investment less land and working capital			855,700	12.9
Average cost of capital and taxes at 8.6% of total capital investment			1,089,600	16.5
Overhead				
Plant, 50% of conversion costs less utilities			865,700	13.1
Administrative, 10% of operating labor			133,200	2.0
Subtotal indirect costs			2,944,200	44.5
Total annual revenue requirements			6,619,600	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	15.13	7.57	1.89

a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $12,670,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-133. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: constrained pond acreage, 200-MW plant)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	1,405	12.7	6.7
Piping and insulation	179	1.6	0.9
Transport lines	451	4.0	2.2
Foundation and structural	116	1.0	0.6
Excavation, site preparation, roads and railroads	141	1.3	0.7
Electrical	795	7.1	3.8
Instrumentation	100	0.9	0.5
Buildings	115	1.0	0.6
Subtotal	3,302	29.6	16.0
Services and miscellaneous	50	0.4	0.2
Subtotal excluding pond	3,352	30.0	16.2
Pond construction	7,838	70.0	37.9
Subtotal direct investment	11,190	100.0	54.1
Engineering design and supervision	809	7.2	3.9
Architect and engineering contractor	157	1.4	0.7
Construction expense	1,400	12.5	6.7
Contractor fees	602	5.4	2.9
Subtotal	14,158	126.5	68.4
Contingency	2,832	25.3	13.7
Subtotal fixed investment	16,990	151.8	82.1
Allowance for startup and modifications	915	8.2	4.4
Interest during construction	2,039	18.2	9.8
Subtotal capital investment	19,944	178.2	96.3
Land	493	4.4	2.4
Working capital	264	2.4	1.3
Total capital investment	20,701	185.0	100.0

[a] Basis

New 200-MW plant (30-yr life); 141 klb/hr (36% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, pond acreage - 50% of optimum, 96 acres.
Calcilox added at 7% of dry solids.

TABLE A-134. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 200-MW plant, constrained pond acreage - 50% of optimum)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)	1,519 tons	48.00/ton	72,900	1.6
Calcilox	10,623 tons	58.00/ton	616,100	13.9
Subtotal raw materials cost			689,000	15.6
Conversion costs				
Operating labor and supervision	26,280 man-hr	12.50/man-hr	328,500	7.4
Maintenance				
Labor and materials				
4% of direct investment (plant)			134,100	3.0
3% of direct investment (pond)			235,100	5.3
Electricity	2,130 kkWh	0.031/kWh	66,000	1.5
Analyses	1,000 hr	17.00/hr	17,000	0.4
Subtotal conversion costs			780,700	17.7
Subtotal direct costs			1,469,700	33.2
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			781,900	17.7
Average cost of capital and taxes at 8.6% of total capital investment			1,780,300	40.2
Overhead				
Plant, 50% of conversion costs less utilities			357,400	8.1
Administrative, 10% of operating labor			33,900	0.8
Subtotal indirect costs			2,953,500	66.8
Total annual revenue requirements			4,423,200	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	24.78	12.39	3.16

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a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $20,701,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-135. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: disposal pond acreage constrained, 200-MW plant)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	1,405	15.8	8.1
Piping and insulation	179	2.0	1.0
Transport lines	451	5.1	2.6
Foundation and structural	116	1.3	0.7
Excavation, site preparation, roads and railroads	141	1.6	0.8
Electrical	795	8.9	4.6
Instrumentation	100	1.1	0.6
Buildings	115	1.3	0.7
Subtotal	3,302	37.1	19.1
Services and miscellaneous	50	0.6	0.3
Subtotal excluding pond	3,352	37.7	19.4
Pond construction	5,537	62.3	32.0
Subtotal direct investment	8,889	100.0	51.4
Engineering design and supervision	746	8.4	4.3
Architect and engineering contractor	151	1.7	0.9
Construction expense	1,220	13.7	7.0
Contractor fees	505	5.7	2.9
Subtotal	11,511	129.5	66.5
Contingency	2,302	25.9	13.3
Subtotal fixed investment	13,813	155.4	79.8
Allowance for startup and modifications	828	9.3	4.8
Interest during construction	1,658	18.7	9.6
Subtotal capital investment	16,299	183.4	94.2
Land	742	8.3	4.3
Working capital	264	3.0	1.5
Total capital investment	17,305	194.7	100.0

[a] Basis

New 200-MW plant (30-yr life); 141 klb/hr (36% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, pond acreage - 75% of optimum, 145 acres.
Calcilox added at 7% of dry solids.

TABLE A-136. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 200-MW plant, constrained pond acreage - 75% of optimum)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)			72,900	1.8
Calcilox			616,100	14.9
Subtotal raw materials cost			689,000	16.7
Conversion costs				
Operating labor and supervision	26,280 man-hr	12.50/man-hr	328,500	7.9
Maintenance				
Labor and materials				
4% of direct investment (plant)			134,100	3.2
3% of direct investment (pond)			166,100	4.0
Electricity	2,130 kkWh	0.031/kWh	66,000	1.6
Analyses	1,000 hr	17.00/hr	17,000	0.4
Subtotal conversion costs			652,300	15.9
Subtotal direct costs			1,341,300	32.4
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			977,900	23.7
Average cost of capital and taxes at 8.6% of total capital investment			1,488,200	36.0
Overhead				
Plant, 50% of conversion costs less utilities			293,200	7.09
Administrative, 10% of operating labor			32,900	0.8
Subtotal indirect costs			2,792,200	67.6
Total annual revenue requirements			4,133,500	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	23.16	72.39	2.95

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a. Basis
Remaining plant life, 30 yr.
Coal burned, 175,238 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $17,305,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-137. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: constrained pond acreage)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,272	10.7	6.1
Piping and insulation	262	1.2	0.7
Transport lines	657	3.1	1.7
Foundation and structural	313	1.5	0.8
Excavation, site preparation, roads and railroads	164	0.8	0.4
Electrical	974	4.6	2.6
Instrumentation	113	0.5	0.3
Buildings	115	0.5	0.3
Subtotal	4,870	22.9	12.9
Services and miscellaneous	73	0.3	0.2
Subtotal excluding pond	4,943	23.2	13.1
Pond construction	16,361	76.8	43.4
Subtotal direct investment	21,304	100.0	56.5
Engineering design and supervision	1,024	4.8	2.7
Architect and engineering contractor	182	0.9	0.5
Construction expense	2,265	10.6	6.0
Contractor fees	982	4.6	2.6
Subtotal	25,757	120.9	68.3
Contingency	5,151	24.2	13.7
Subtotal fixed investment	30,908	145.1	82.0
Allowance for startup and modifications	1,455	6.8	3.9
Interest during construction	3,709	17.4	9.8
Subtotal capital investment	36,072	169.3	95.7
Land	1,075	5.0	2.8
Working capital	550	2.6	1.5
Total capital investment	37,697	176.9	100.0

a. Basis
New 500-MW plant (30-yr life); 347 klb/hr (36% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, pond acreage - 50% of optimum, 207 acres.
Calcilox added at 7% of dry solids.

TABLE A-138. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: constrained pond acreage - 50% of optimum)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)			194,500	2.1
Calcilox			1,645,900	18.1
Subtotal raw materials cost			1,840,400	20.2
Conversion costs				
Operating labor and supervision	35,040 man-hr	12.50/man-hr	438,000	4.8
Maintenance				
Labor and materials				
4% of direct investment (plant)			197,700	11.2
3% of direct investment (pond)			490,800	5.4
Electricity	3,577 kkWh	0.029/kWh	103,700	1.1
Analyses	1,000 hr	17.00/hr	17,000	0.2
Subtotal conversion costs			1,247,200	13.7
Subtotal direct costs			3,087,600	33.9
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			2,164,300	23.8
Average cost of capital and taxes at 8.6% of total capital investment			3,241,900	35.6
Overhead				
Plant, 50% of conversion costs less utilities			571,800	6.3
Administrative, 10% of operating labor			43,800	0.5
Subtotal indirect costs			6,021,800	66.1
Total annual revenue requirements			9,109,400	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	20.82	10.41	2.60

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a. Basis
Remaining plant life, 30 yr.
Coal burned, 175,238 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $37,697,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-139. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: constrained pond acreage)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,272	13.6	7.4
Piping and insulation	262	1.6	0.8
Transport lines	657	3.9	2.1
Foundation and structural	313	1.9	1.0
Excavation, site preparation, roads and railroads	164	1.0	0.5
Electrical	974	5.8	3.1
Instrumentation	113	0.7	0.4
Buildings	115	0.7	0.4
Subtotal	4,870	29.2	15.7
Services and miscellaneous	73	0.4	0.2
Subtotal excluding pond	4,943	29.6	15.9
Pond construction	11,740	70.4	37.8
Subtotal direct investment	16,683	100.0	53.7
Engineering design and supervision	926	5.6	3.0
Architect and engineering contractor	173	1.0	0.6
Construction expense	1,946	11.6	6.2
Contractor fees	815	4.9	2.6
Subtotal	20,543	123.1	66.1
Contingency	4,109	24.7	13.3
Subtotal fixed investment	24,652	147.8	79.4
Allowance for startup and modifications	1,291	7.7	4.2
Interest during construction	2,958	17.7	9.4
Subtotal capital investment	28,901	173.2	93.0
Land	1,610	9.7	5.2
Working capital	550	3.3	1.8
Total capital investment	31,061	186.2	100.0

a. Basis
New 500-MW plant (30-yr life); 347 klb/hr (36% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, pond acreage - 75% of optimum, 310 acres.
Calcilox added at 7% of dry solids.

TABLE A-140. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: constrained pond acreage - 75% of optimum)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)			194,500	2.5
Calcilox			1,645,900	20.8
Subtotal raw materials cost			1,840,400	23.3
Conversion costs				
Operating labor and supervision	35,040 man-hr	12.50/man-hr	438,000	5.5
Maintenance				
Labor and materials				
4% of direct investment (plant)			197,700	2.5
3% of direct investment (pond)			352,200	4.5
Electricity	3,577 kkWh	0.025/kWh	103,700	1.3
Analyses	1,000 hr	17.00/hr	17,000	0.2
Subtotal conversion costs			1,108,600	14.0
Subtotal direct costs			2,949,000	37.3
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			1,734,100	21.9
Average cost of capital and taxes at 8.6% of total capital investment			2,671,200	33.8
Overhead				
Plant, 50% of conversion costs less utilities			502,500	6.4
Administrative, 10% of operating labor			43,800	0.6
Subtotal indirect costs			4,951,600	62.7
Total annual revenue requirements			7,900,600	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	18.06	9.03	2.25	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $31,061,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-141. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: constrained pond acreage, 1500-MW plant)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	4,363	9.3	5.4
Piping and insulation	424	0.9	0.5
Transport lines	978	2.1	1.2
Foundation and structural	540	1.1	0.7
Excavation, site preparation, roads and railroads	241	0.5	0.3
Electrical	1,301	2.8	1.6
Instrumentation	119	0.3	0.2
Buildings	115	0.2	0.2
Subtotal	8,081	17.2	10.1
Services and miscellaneous	121	0.3	0.1
Subtotal excluding pond	8,202	17.4	10.2
Pond construction	38,813	82.6	48.5
Subtotal direct investment	47,015	100.0	58.7
Engineering design and supervision	1,504	3.2	1.9
Architect and engineering contractor	244	0.5	0.3
Construction expense	4,143	8.8	5.2
Contractor fees	1,791	3.8	2.2
Subtotal	54,697	116.3	68.3
Contingency	10,939	23.3	13.6
Subtotal fixed investment	65,636	139.6	81.9
Allowance for startup and modifications	2,682	5.7	3.4
Interest during construction	7,876	16.8	9.8
Subtotal capital investment	76,194	162.1	95.1
Land	2,517	5.3	3.2
Working capital	1,387	3.0	1.7
Total capital investment	80,098	170.4	100.0

a. Basis

New 1500-MW plant (30-yr life); 1,040 klb/hr (36% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, pond acreage - 50% of optimum, 487 acres.
Calcilox added at 7% of dry solids.

TABLE A-142. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 1500-MW plant, constrained pond acreage - 50% of optimum)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)			538,800	2.9
Calcilox			4,932,900	24.2
Subtotal raw materials cost			5,516,700	27.1
Conversion costs				
Operating labor and supervision	43,800 man-hr	12.50/man-hr	547,500	2.7
Maintenance				
Labor and materials				
4% of direct investment (plant)			328,100	1.6
3% of direct investment (pond)			1,164,400	
Electricity	8,733 kkWh	0.027/kWh	235,800	5.7
Analyses	1,500 hr	17.00/hr	25,500	0.1
Subtotal conversion costs			2,301,300	11.3
Subtotal direct costs			7,818,000	38.4
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			4,571,600	22.4
Average cost of capital and taxes at 8.6% of total capital investment			6,888,400	33.8
Overhead				
Plant, 50% of conversion costs less utilities			1,032,800	5.0
Administrative, 10% of operating labor			54,800	0.3
Subtotal indirect costs			12,547,600	61.6
Total annual revenue requirements			20,365,600	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	15.52	7.76	1.94

a. Basis
Remaining plant life, 30 yr.
Coal burned, 1,285,714 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $80,098,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-143. DRAVO PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: constrained pond acreage, 1500-MW plant)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	4,363	12.2	6.8
Piping and insulation	424	1.2	0.6
Transport lines	978	2.7	1.5
Foundation and structural	540	1.5	0.8
Excavation, site preparation, roads and railroads	241	0.7	0.4
Electrical	1,301	3.6	2.0
Instrumentation	119	0.3	0.2
Buildings	115	0.3	0.2
Subtotal	8,081	22.5	12.5
Services and miscellaneous	121	0.3	0.2
Subtotal excluding pond	8,202	22.8	12.7
Pond construction	27,732	77.2	43.0
Subtotal direct investment	35,934	100.0	55.7
Engineering design and supervision	1,326	3.7	2.1
Architect and engineering contractor	226	0.6	0.3
Construction expense	3,483	9.7	5.4
Contractor fees	1,460	4.1	2.3
Subtotal	42,469	118.1	65.8
Contingency	8,486	23.6	13.1
Subtotal fixed investment	50,915	141.7	78.9
Allowance for startup and modifications	2,318	6.5	3.6
Interest during construction	6,110	16.9	9.5
Subtotal capital investment	59,343	165.1	92.0
Land	3,773	10.5	5.8
Working capital	1,387	3.9	2.2
Total capital investment	64,503	179.5	100.0

a. Basis

New 1500-MW plant (30-yr life); 1,040 klb/hr (36% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Pond characteristics: clay-lined, 1 mi from scrubber facilities, 50% solids settled density, pond acreage - 75% of optimum, 731 acres.
Calcilox added at 7% of dry solids.

TABLE A-144. DRAVO PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 1500-MW plant, constrained pond acreage - 75% of optimum)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (pebble)			583,800	3.4
Calcilox			4,932,900	28.5
Subtotal raw materials cost			5,516,700	31.9
Conversion costs				
Operating labor and supervision	43,800 man-hr	12.50/man-hr	547,500	3.2
Maintenance				
Labor and materials				
4% of direct investment (plant)			328,100	1.9
3% of direct investment (pond)			682,000	3.9
Electricity	8,733 kkWh	0.027/kWh	235,800	1.4
Analyses	1,500 hr	17.00/hr	25,500	0.1
Subtotal conversion costs			1,818,900	10.5
Subtotal direct costs			7,355,600	42.4
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 6% of total capital investment less land and working capital			3,560,600	20.6
Average cost of capital and taxes at 8.6% of total capital investment			5,547,300	32.1
Overhead				
Plant, 50% of conversion costs less utilities			791,600	4.6
Administrative, 10% of operating labor			54,800	0.3
Subtotal indirect costs			9,954,300	57.6
Total annual revenue requirements			17,289,900	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	13.17	6.59	1.65

a. Basis
Remaining plant life, 30 yr.
Coal burned, 1,285,714 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $64,503,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-145. IUCS PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Base case)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,551	52.2	23.7
Piping and insulation	176	3.6	1.6
Transport lines	-	-	-
Foundation and structural	136	2.8	1.3
Excavation, site preparation, roads and railroads	115	2.4	1.1
Electrical	639	13.1	6.0
Instrumentation	70	1.4	0.7
Buildings	550	11.3	5.1
Subtotal	4,237	86.8	39.5
Services and miscellaneous	64	1.3	0.6
Subtotal excluding trucks and equipment	4,301	88.1	40.1
Trucks and earthmoving equipment	581	11.9	5.4
Subtotal direct investment	4,882	100.0	45.5
Engineering design and supervision	392	8.0	3.7
Architect and engineering contractor	98	2.0	0.9
Construction expense	839	17.2	7.8
Contractor fees	320	6.6	3.0
Subtotal	6,531	133.8	60.9
Contingency	1,306	26.7	12.2
Subtotal fixed investment	7,837	160.5	73.1
Allowance for startup and modifications	726	14.9	6.8
Interest during construction	940	19.3	8.8
Subtotal capital investment	9,503	194.7	88.7
Land	676	13.8	6.3
Working capital	538	11.0	5.0
Total capital investment	10,717	219.5	100.0

a. Basis

New 500-MW plant (30-yr life); 198 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities, 60% solids cake.
Land required for disposal, 193 acres at 30 ft deep.
Trucks used for transport of treated sludge to disposal area.
Lime added at 4% of dry solids.

TABLE A-146. IUCS PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Base case)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (ground)	16,216 tons	53.00/ton	859,400	16.2
Subtotal raw materials cost			859,400	16.2
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	8.3
Solids disposal equipment	52,560 man-hr	17.00/man-hr	893,500	16.9
Maintenance--plant labor and material, 4% of direct investment			172,000	3.3
Landfill operation				
Land preparation			11,000	0.2
Trucks (fuel and maintenance)	693,000 tons	0.06/ton	41,600	0.8
Earthmoving equipment (fuel and maintenance)	693,000 tons	0.16/ton	110,900	2.1
Electricity	3,688 kkWh	0.029/kWh	107,000	2.0
Analyses	1,000 hr	17.00/man-hr	17,000	0.3
Subtotal conversion costs			1,791,000	33.0
Subtotal direct costs			2,650,400	50.1
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			744,100	14.1
Average cost of capital and taxes at 8.6% of total capital investment			921,700	17.4
Overhead				
Plant, 50% of conversion costs less utilities			842,000	15.9
Administrative, 10% of operating labor			133,200	2.5
Subtotal indirect costs			2,641,000	49.9
Total annual revenue requirements			5,291,400	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	12.55	7.63	1.51

a. Basis
Remaining plant life, 30 yr.
Coal burned, 482,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $10,717,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-147. IUCS PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: 200-MW plant)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	1,520	46.3	21.1
Piping and insulation	126	3.8	1.8
Transport lines	-	-	-
Foundation and structural	65	2.0	0.9
Excavation, site preparation, roads and railroads	94	2.9	1.3
Electrical	430	13.1	6.0
Instrumentation	56	1.7	0.8
Buildings	550	16.7	7.6
Subtotal	2,841	86.5	39.5
Services and miscellaneous	43	1.3	0.6
Subtotal excluding trucks and equipment	2,884	87.8	40.1
Trucks and earthmoving equipment	400	12.2	5.6
Subtotal direct investment	3,284	100.0	45.7
Engineering design and supervision	311	9.5	4.3
Architect and engineering contractor	78	2.4	1.1
Construction expense	602	18.3	8.3
Contractor fees	237	7.2	3.3
Subtotal	4,512	137.4	62.7
Contingency	902	27.5	12.6
Subtotal fixed investment	5,414	164.9	75.3
Allowance for startup and modifications	501	15.3	7.0
Interest during construction	650	19.7	9.0
Subtotal capital investment	6,565	199.9	91.3
Land	280	8.5	3.9
Working capital	348	10.6	4.8
Total capital investment	7,193	219.0	100.0

[a] Basis
New 200-MW plant (30-yr life); 81 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities, 60% solids cake.
Land required for disposal, 80 acres at 30 ft deep.
Trucks used for transport of treated sludge to disposal area.
Lime added at 4% of dry solids.

TABLE A-148. IUCS PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 200-MW plant)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (ground)	6,633 tons	53.00/ton	351,500	9.8
Subtotal raw materials cost			351,500	9.8
Conversion costs				
Operating labor and supervision				
Plant	26,280 man-hr	12.50/man-hr	328,500	9.2
Solids disposal equipment	43,800 man-hr	17.00/man-hr	744,600	20.9
Maintenance--plant labor and material, 4% of direct investment			115,400	3.2
Landfill operation				
Land preparation			5,000	0.1
Trucks (fuel and maintenance)	283,500 tons	0.06/ton	17,000	0.5
Earthmoving equipment (fuel and maintenance)	283,500 tons	0.16/ton	45,400	1.3
Electricity	2,141 kkWh	0.031/kWh	66,400	1.9
Analyses	1,000 hr	17.00/man-hr	17,000	0.5
Subtotal conversion costs			1,339,300	37.6
Subtotal direct costs			1,690,800	47.4
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			514,000	14.4
Average cost of capital and taxes at 8.6% of total capital investment			618,600	17.3
Overhead				
Plant, 50% of conversion costs less utilities			636,500	17.9
Administrative, 10% of operating labor			107,300	3.0
Subtotal indirect costs			1,876,400	52.6
Total annual revenue requirements			3,567,200	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	20.68	12.59	2.55

a. Basis
Remaining plant life, 30 yr.
Coal burned, 175,238 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $7,193,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-149. IUCS PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 200-MW plant, 25-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	1,625	47.1	21.8
Piping and insulation	127	3.7	1.7
Transport lines	-	-	-
Foundation and structural	71	2.1	1.0
Excavation, site preparation, roads and railroads	97	2.8	1.3
Electrical	431	12.5	5.8
Instrumentation	56	1.6	0.8
Buildings	550	15.9	7.4
Subtotal	2,957	85.7	39.8
Services and miscellaneous	44	1.2	0.6
Subtotal excluding trucks and equipment	3,001	86.9	40.4
Trucks and earthmoving equipment	451	13.1	6.1
Subtotal direct investment	3,452	100.0	46.5
Engineering design and supervision	322	9.3	4.3
Architect and engineering contractor	81	2.3	1.1
Construction expense	622	18.1	8.4
Contractor fees	246	7.1	3.3
Subtotal	4,723	136.8	63.6
Contingency	945	27.4	12.7
Subtotal fixed investment	5,668	164.2	76.3
Allowance for startup and modifications	522	15.1	7.0
Interest during construction	680	19.7	9.2
Subtotal capital investment	6,870	199.0	92.5
Land	207	6.0	2.8
Working capital	351	10.2	4.7
Total capital investment	7,428	215.2	100.0

a. Basis
Existing 200-MW plant (25-yr remaining life); 83 klb/hr (60% solids) sludge .
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities, 60% solids cake.
Land required for disposal, 50 acres at 30 ft deep.
Trucks used for transport of treated sludge to disposal area.
Lime added at 4% of dry solids.

TABLE A-150. IUCS PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS -- REGULATED UTILITY ECONOMICS

(Variation from base case: existing 200-MW plant, 25-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (ground)	6,846 tons	53.00/ton	362,800	9.8
Subtotal raw materials cost			362,800	9.8
Conversion costs				
Operating labor and supervision				
Plant	26,280 man-hr	12.50/man-hr	328,500	8.9
Solids disposal equipment	43,800 man-hr	17.00/man-hr	744,600	20.1
Maintenance--plant labor and material, 4% of direct investment			120,000	3.2
Landfill operation				
Land preparation			4,000	0.1
Trucks (fuel and maintenance)	290,500 tons	0.06/ton	17,400	0.5
Earthmoving equipment (fuel and maintenance)	290,500 tons	0.16/ton	46,500	1.3
Electricity	2,196 kkWh	0.031/kWh	68,100	1.8
Analyses	1,000 hr	17.00/man-hr	17,000	0.5
Subtotal conversion costs			1,346,100	36.4
Subtotal direct costs			1,708,900	46.2
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 8.8% of total capital investment less land and working capital			604,600	16.3
Average cost of capital and taxes at 8.6% of total capital investment			638,800	17.3
Overhead				
Plant, 50% of conversion costs less utilities			639,000	17.3
Administrative, 10% of operating labor			107,300	2.9
Subtotal indirect costs			1,989,700	53.8
Total annual revenue requirements			3,698,600	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	20.66	12.73	2.64

a. Basis
Remaining plant life, 25 yr.
Coal burned, 180,952 lb/hr, 9,500 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $7,428,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-151. IUCS PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 200-MW plant, 20-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	1,625	47.0	22.0
Piping and insulation	127	3.7	1.7
Transport lines	-	-	-
Foundation and structural	71	2.1	1.0
Excavation, site preparation, roads and railroads	97	2.8	1.3
Electrical	431	12.5	5.9
Instrumentation	56	1.6	0.8
Buildings	550	15.9	7.5
Subtotal	2,957	85.6	40.2
Services and miscellaneous	44	1.3	0.6
Subtotal excluding trucks and equipment	3,001	86.9	40.8
Trucks and earthmoving equipment	451	13.1	6.2
Subtotal direct investment	3,452	100.0	47.0
Engineering design and supervision	322	9.3	4.4
Architect and engineering contractor	81	2.3	1.1
Construction expense	622	18.1	8.4
Contractor fees	246	7.1	3.3
Subtotal	4,723	136.8	64.2
Contingency	945	27.4	12.9
Subtotal fixed investment	5,668	164.2	77.1
Allowance for startup and modifications	522	15.1	7.1
Interest during construction	680	19.7	9.3
Subtotal capital investment	6,870	199.0	93.5
Land	130	3.8	1.8
Working capital	351	10.1	4.7
Total capital investment	7,351	212.9	100.0

a. Basis

Existing 200-MW plant (20-yr remaining life); 83 klb/hr (60% solids) sludge.

Midwest plant location; average basis for cost scaling, mid-1979.

Coal analysis (by wt): 3.5% S (dry basis), 16% ash.

Flyash removed with SO_2.

SO_2 and flyash removed to meet NSPS.

Limestone process with 1.5 stoichiometry based on SO_2 removed.

Disposal in landfill 1 mi from scrubber facilities, 60% solids cake.

Land required for disposal, 37 acres at 30 ft deep.

Trucks used for transport of treated sludge to disposal area.

Lime added at 4% of dry solids.

TABLE A-152. IUCS PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 200-MW plant, 20-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (ground)	6,846 tons	53.00/ton	362,800	9.8
Subtotal raw materials cost			362,800	9.8
Conversion costs				
Operating labor and supervision				
Plant	26,280 man-hr	12.50/man-hr	328,500	8.8
Solids disposal equipment	43,800 man-hr	17.00/man-hr	744,600	20.0
Maintenance--plant labor and material, 4% of direct investment			120,000	3.2
Landfill operation				
Land preparation			3,100	0.1
Trucks (fuel and maintenance)	290,500 tons	0.06/ton	17,400	0.5
Earthmoving equipment (fuel and maintenance)	290,500 tons	0.16/ton	46,500	1.2
Electricity	2,196 kkWh	0.031/kWh	68,100	1.8
Analyses	1,000 hr	17.00/man-hr	17,000	0.5
Subtotal conversion costs			1,345,200	36.1
Subtotal direct costs			1,708,000	45.9
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 9.3% of total capital investment less land and working capital			638,900	17.1
Average cost of capital and taxes at 8.6% of total capital investment			632,000	17.0
Overhead				
Plant, 50% of conversion costs less utilities			638,600	17.1
Administrative, 10% of operating labor			107,300	2.9
Subtotal indirect costs			2,017,000	54.1
Total annual revenue requirements			3,725,000	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	20.80	12.82	2.66

a. Basis
Remaining plant life, 20 yr.
Coal burned, 180,952 lb/hr, 9,500 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $7,351,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-153. IUCS PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 200-MW plant, 15-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	1,625	47.0	22.3
Piping and insulation	127	3.7	1.7
Transport lines	-	-	-
Foundation and structural	71	2.1	1.0
Excavation, site preparation, roads and railroads	97	2.8	1.3
Electrical	431	12.5	5.9
Instrumentation	56	1.6	0.8
Buildings	550	15.9	7.5
Subtotal	2,957	85.7	40.5
Services and miscellaneous	44	1.2	0.6
Subtotal excluding trucks and equipment	3,001	86.9	41.1
Trucks and earthmoving equipment	451	13.1	6.2
Subtotal direct investment	3,452	100.0	47.3
Engineering design and supervision	322	9.3	4.4
Architect and engineering contractor	81	2.3	1.1
Construction expense	622	18.1	8.5
Contractor fees	246	7.1	3.4
Subtotal	4,723	136.8	64.7
Contingency	945	27.4	13.0
Subtotal fixed investment	5,668	164.2	77.7
Allowance for startup and modifications	522	15.1	7.2
Interest during construction	680	19.7	9.3
Subtotal capital investment	6,870	199.0	94.2
Land	74	2.1	1.0
Working capital	351	10.2	4.8
Total capital investment	7,295	211.3	100.0

a. Basis

Existing 200-MW plant (15-yr remaining life) 83 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities, 60% solids cake.
Land required for disposal, 21 acres at 30 ft deep.
Trucks used for transport of treated sludge to disposal area.
Lime added at 4% of dry solids.

TABLE A-154. IUCS PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 200-MW plant, 15-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (ground)	6,846 tons	53.00/ton	362,800	9.5
Subtotal raw materials cost			362,800	9.5
Conversion costs				
Operating labor and supervision				
Plant	26,280 man-hr	12.50/man-hr	328,500	8.6
Solids disposal equipment	43,800 man-hr	17.00/man-hr	744,600	19.5
Maintenance--plant labor and material, 4% of direct investment			120,000	3.1
Landfill operation				
Land preparation			2,400	0.1
Trucks (fuel and maintenance)	290,500 tons	0.06/ton	17,400	0.5
Earthmoving equipment (fuel and maintenance)	290,500 tons	0.16/ton	46,500	1.2
Electricity	2,196 kkWh	0.037/kWh	68,100	1.8
Analyses	1,000 hr	17.00/man-hr	17,000	0.4
Subtotal conversion costs			1,344,500	35.2
Subtotal direct costs			1,707,300	44.7
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 10.8% of total capital investment less land and working capital			742,000	19.4
Average cost of capital and taxes at 8.6% of total capital investment			627,400	16.4
Overhead				
Plant, 50% of conversion costs less utilities			638,200	16.7
Administrative, 10% of operating labor			107,300	2.8
Subtotal indirect costs			2,114,900	55.3
Total annual revenue requirements			3,822,200	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	21.35	13.16	2.73

[a] Basis
Remaining plant life, 15 yr.
Coal burned, 180,952 lb/hr, 9,500 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $7,295,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-155. IUCS PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 500-MW plant, 25-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,565	52.3	24.1
Piping and insulation	176	3.6	1.7
Transport lines	-	-	-
Foundation and structural	140	2.9	1.3
Excavation, site preparation, roads and railroads	116	2.4	1.1
Electrical	645	13.1	6.1
Instrumentation	70	1.4	0.7
Buildings	550	11.2	5.2
Subtotal	4,262	86.9	40.2
Services and miscellaneous	64	1.3	0.6
Subtotal excluding trucks and equipment	4,326	88.2	40.8
Trucks and earthmoving equipment	581	11.8	5.5
Subtotal direct investment	4,907	100.0	46.3
Engineering design and supervision	392	8.0	3.7
Architect and engineering contractor	98	2.0	0.9
Construction expense	843	17.1	8.1
Contractor fees	322	6.6	3.0
Subtotal	6,562	133.7	62.0
Contingency	1,312	26.8	12.4
Subtotal fixed investment	7,874	160.5	74.4
Allowance for startup and modifications	729	14.9	6.9
Interest during construction	945	19.2	8.9
Subtotal capital investment	9,548	194.6	90.2
Land	501	10.2	4.7
Working capital	542	11.0	5.1
Total capital investment	10,591	215.8	100.0

a. Basis

Existing 500-MW plant (25-yr remaining life); 202 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities, 60% solids cake.
Land required for disposal, 143 acres at 30 ft deep.
Trucks used for transport of treated sludge to disposal area.
Lime added at 4% of dry solids.

TABLE A-156. IUCS PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 500-MW plant, 25-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (ground)	16,576 tons	53.00/ton	878,500	16.3
Subtotal raw materials cost			878,500	16.3
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	8.1
Solids disposal equipment	52,560 man-hr	17.00/man-hr	893,500	16.5
Maintenance--plant labor and material, 4% of direct investment			173,000	3.2
Landfill operation				
Land preparation			9,700	0.2
Trucks (fuel and maintenance)	707,000 tons	0.06/ton	42,400	0.8
Earthmoving equipment (fuel and maintenance)	707,000 tons	0.16/ton	113,100	2.1
Electricity	3,760 kkWh	0.029/kWh	109,000	2.0
Analyses	1,000 hr	17.00/man-hr	17,000	0.3
Subtotal conversion costs			1,795,700	33.2
Subtotal direct costs			2,674,200	49.5
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 8.8% of total capital investment less land and working capital			840,200	15.6
Average cost of capital and taxes at 8.6% of total capital investment			910,800	16.8
Overhead				
Plant, 50% of conversion costs less utilities			843,400	15.6
Administrative, 10% of operating labor			133,200	2.5
Subtotal indirect costs			2,727,600	50.5
Total annual revenue requirements			5,401,800	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	12.55	7.63	1.54

a. Basis
Remaining plant life, 25 yr.
Coal burned, 438,095 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $10,591,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-157. IUCS PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 500-MW plant, 20-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,565	52.3	24.7
Piping and insulation	176	3.6	1.7
Transport lines	-	-	-
Foundation and structural	140	2.9	1.3
Excavation, site preparation, roads and railroads	116	2.4	1.1
Electrical	645	13.1	6.2
Instrumentation	70	1.4	0.7
Buildings	550	11.2	5.3
Subtotal	4,262	86.9	41.0
Services and miscellaneous	64	1.3	0.6
Subtotal excluding trucks and equipment	4,326	88.2	41.6
Trucks and earthmoving equipment	581	11.8	5.6
Subtotal direct investment	4,907	100.0	47.2
Engineering design and supervision	392	8.0	3.8
Architect and engineering contractor	98	2.0	0.9
Construction expense	843	17.1	8.1
Contractor fees	322	6.6	3.1
Subtotal	6,562	133.7	63.1
Contingency	1,312	26.8	12.6
Subtotal fixed investment	7,874	160.5	75.7
Allowance for startup and modifications	729	14.9	7.0
Interest during construction	945	19.2	9.1
Subtotal capital investment	9,548	194.6	91.8
Land	312	6.4	3.0
Working capital	542	11.0	5.2
Total capital investment	10,402	212.0	100.0

[a] Basis
Existing 500-MW plant (20-yr remaining life); 202 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities, 60% solids cake.
Land required for disposal, 89 acres at 30 ft deep.
Trucks used for transport of treated sludge to disposal area.
Lime added at 4% of dry solids.

TABLE A-158. IUCS PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 500-MW plant, 20-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (ground)	16,576 tons	53.00/ton	878,500	16.2
Subtotal raw materials cost			878,500	16.2
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	8.1
Solids disposal equipment	52,560 man-hr	17.00/man-hr	893,500	16.4
Maintenance--plant labor and material, 4% of direct investment			173,000	3.2
Landfill operation				
Land preparation			7,600	0.1
Trucks (fuel and maintenance)	707,000 tons	0.06/ton	42,400	0.8
Earthmoving equipment (fuel and maintenance)	707,000 tons	0.16/ton	113,100	2.1
Electricity	3,760 kkWh	0.029/kWh	109,000	2.0
Analyses	1,000 hr	17.00/man-hr	17,000	0.3
Subtotal conversion costs			1,793,600	33.0
Subtotal direct costs			2,672,100	49.2
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 9.3% of total capital investment less land and working capital			888,000	16.4
Average cost of capital and taxes at 8.6% of total capital investment			894,600	16.5
Overhead				
Plant, 50% of conversion costs less utilities			842,300	15.5
Administrative, 10% of operating labor			133,200	2.4
Subtotal indirect costs			2,758,100	50.8
Total annual revenue requirements			5,430,200	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	12.62	7.68	1.55

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a. Basis

Remaining plant life, 20 yr.
Coal burned, 438,095 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $10,402,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-159. IUCS PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 500-MW plant, 15-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,565	52.3	24.9
Piping and insulation	176	3.6	1.7
Transport lines	-	-	-
Foundation and structural	140	2.9	1.4
Excavation, site preparation, roads and railroads	116	2.4	1.1
Electrical	645	13.1	6.3
Instrumentation	70	1.4	0.7
Buildings	550	11.2	5.4
Subtotal	4,262	86.9	41.5
Services and miscellaneous	64	1.3	0.6
Subtotal excluding trucks and equipment	4,326	88.2	42.1
Trucks and earthmoving equipment	581	11.8	5.7
Subtotal direct investment	4,907	100.0	47.8
Engineering design and supervision	392	8.0	3.8
Architect and engineering contractor	98	2.0	1.0
Construction expense	843	17.1	8.2
Contractor fees	322	6.6	3.1
Subtotal	6,562	133.7	63.9
Contingency	1,312	26.8	12.8
Subtotal fixed investment	7,874	160.5	76.7
Allowance for startup and modifications	729	14.9	7.1
Interest during construction	945	19.2	9.2
Subtotal capital investment	9,548	194.6	93.0
Land	179	3.6	1.7
Working capital	542	11.1	5.3
Total capital investment	10,269	209.3	100.0

a. Basis

Existing 500-MW plant (15-yr remaining life); 202 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities, 60% solids cake.
Land required for disposal, 51 acres at 30 ft deep.
Trucks used for transport of treated sludge to disposal area.
Lime added at 4% of dry solids.

TABLE A-160. IUCS PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 500-MW plant, 15-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (ground)	16,576 tons	53.00/ton	878,500	15.8
Subtotal raw materials cost			878,500	15.8
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	7.9
Solids disposal equipment	52,560 man-hr	17.00/man-hr	893,500	16.0
Maintenance--plant labor and material, 4% of direct investment			173,000	3.1
Landfill operation				
Land preparation			5,800	0.1
Trucks (fuel and maintenance)	707,000 tons	0.06/ton	42,400	0.8
Earthmoving equipment (fuel and maintenance)	707,000 tons	0.16/ton	113,100	2.0
Electricity	3,760 kkWh	0.029/kWh	109,000	2.0
Analyses	1,000 hr	17.00/man-hr	17,000	0.3
Subtotal conversion costs			1,791,800	32.2
Subtotal direct costs			2,670,300	48.0
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 10.8% of total capital investment less land and working capital			1,031,200	18.6
Average cost of capital and taxes at 8.6% of total capital investment			883,100	15.9
Overhead				
Plant, 50% of conversion costs less utilities			841,400	15.1
Administrative, 10% of operating labor			133,200	2.4
Subtotal indirect costs			2,889,900	52.0
Total annual revenue requirements			5,559,200	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	12.92	7.86	1.59	

[a] Basis
Remaining plant life, 15 yr.
Coal burned, 438,095 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $10,269,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-161. IUCS PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: 1500-MW plant)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	5,050	55.5	25.1
Piping and insulation	287	3.2	1.4
Transport lines	-	-	-
Foundation and structural	314	3.5	1.6
Excavation, site preparation, roads and railroads	180	2.0	0.9
Electrical	1,012	11.1	5.0
Instrumentation	74	0.8	0.4
Buildings	1,004	11.0	5.0
Subtotal	7,921	87.1	39.4
Services and miscellaneous	119	1.3	0.6
Subtotal excluding trucks and equipment	8,040	88.4	40.0
Trucks and earthmoving equipment	1,057	11.6	5.2
Subtotal direct investment	9,097	100.0	45.2
Engineering design and supervision	495	5.4	2.5
Architect and engineering contractor	124	1.4	0.6
Construction expense	1,410	15.5	7.0
Contractor fees	514	5.7	2.6
Subtotal	11,640	128.0	57.9
Contingency	2,328	25.5	11.6
Subtotal fixed investment	13,968	153.5	69.5
Allowance for startup and modifications	1,291	14.2	6.4
Interest during construction	1,676	18.5	8.3
Subtotal capital investment	16,935	186.2	84.2
Land	2,030	22.3	10.1
Working capital	1,140	12.5	5.7
Total capital investment	20,105	221.0	100.0

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a. Basis

New 1500-MW plant (30-yr life); 593 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities, 60% solids cake.
Land required for disposal, 580 acres at 30 ft deep.
Trucks used for transport of treated sludge to disposal area.
Lime added at 4% of dry solids.

TABLE A-162. IUCS PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 1500-MW plant)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (ground)	49,000 tons	53.00/ton	2,597,000	24.9
Subtotal raw materials cost			2,597,000	24.9
Conversion costs				
Operating labor and supervision				
Plant	43,800 man-hr	12.50/man-hr	547,500	5.3
Solids disposal equipment	87,600 man-hr	17.00/man-hr	1,489,200	14.3
Maintenance--plant labor and material, 4% of direct investment			321,600	3.1
Landfill operation				
Land preparation			33,000	0.3
Trucks (fuel and maintenance)	2,075,500 tons	0.06/ton	124,500	1.2
Earthmoving equipment (fuel and maintenance)	2,075,500 tons	0.16/ton	332,100	3.2
Electricity	9,073 kkWh	0.027/kWh	244,900	2.4
Analyses	1,500 hr	17.00/man-hr	25,500	0.2
Subtotal conversion costs			3,118,300	30.0
Subtotal direct costs			5,715,300	54.9
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			1,326,000	12.7
Average cost of capital and taxes at 8.6% of total capital investment			1,729,000	16.6
Overhead				
Plant, 50% of conversion costs less utilities			1,436,700	13.8
Administrative, 10% of operating labor			203,700	2.0
Subtotal indirect costs			4,695,400	45.1
Total annual revenue requirements			10,410,700	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	8.23	5.02	0.99

a. Basis
Remaining plant life, 30 yr.
Coal burned, 1,285,714 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $20,105,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-163. IUCS PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 1500-MW plant, 25-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	5,247	56.3	26.3
Piping and insulation	287	3.1	1.4
Transport lines	-	-	-
Foundation and structural	314	3.4	1.6
Excavation, site preparation, roads and railroads	183	2.0	0.9
Electrical	1,016	10.9	5.1
Instrumentation	74	0.8	0.4
Buildings	1,004	10.8	5.0
Subtotal	8,125	87.3	40.7
Services and miscellaneous	122	1.3	0.6
Subtotal excluding trucks and equipment	8,247	88.6	41.3
Trucks and earthmoving equipment	1,057	11.4	5.3
Subtotal direct investment	9,304	100.0	46.6
Engineering design and supervision	495	5.3	2.5
Architect and engineering contractor	124	1.3	0.6
Construction expense	1,440	15.6	7.3
Contractor fees	523	5.6	2.6
Subtotal	11,886	127.8	59.6
Contingency	2,377	25.5	11.9
Subtotal fixed investment	14,263	153.3	71.5
Allowance for startup and modifications	1,321	14.2	6.6
Interest during construction	1,712	18.4	8.6
Subtotal capital investment	17,296	185.9	86.7
Land	1,505	16.2	7.5
Working capital	1,151	12.3	5.8
Total capital investment	19,952	214.4	100.0

a. Basis

Existing 1500-MW plant (25-yr remaining life); 606 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities, 60% solids cake.
Land required for disposal, 430 acres at 30 ft deep.
Trucks used for transport of treated sludge to disposal area.
Lime added at 4% of dry solids.

TABLE A-164. IUCS PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 1500-MW plant, 25-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (ground)	49,728 tons	53.00/ton	2,635,600	24.7
Subtotal raw materials cost			2,635,600	24.7
Conversion costs				
Operating labor and supervision				
Plant	43,800 man-hr	12.50/man-hr	547,500	5.1
Solids disposal equipment	87,600 man-hr	17.00/man-hr	1,489,200	14.1
Maintenance--plant labor and material, 4% of direct investment			329,900	3.1
Landfill operation				
Land preparation			29,200	0.3
Trucks (fuel and maintenance)	2,121,000 tons	0.06/ton	127,300	1.2
Earthmoving equipment (fuel and maintenance)	2,121,000 tons	0.16/ton	339,400	3.2
Electricity	9,152 kkWh	0.027/kWh	247,100	2.3
Analyses	1,500 hr	17.00/man-hr	25,500	0.2
Subtotal conversion costs			3,135,100	29.5
Subtotal direct costs			5,770,700	54.2
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 8.8% of total capital investment less land and working capital			1,522,000	14.3
Average cost of capital and taxes at 8.6% of total capital investment			1,715,900	16.0
Overhead				
Plant, 50% of conversion costs less utilities			1,444,000	13.6
Administrative, 10% of operating labor			203,700	1.9
Subtotal indirect costs			4,885,600	45.8
Total annual revenue requirements			10,656,300	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	8.24	5.02	1.01	

a. Basis
Remaining plant life, 25 yr.
Coal burned, 1,314,286 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $19,952,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-165. IUCS PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 1500-MW plant, 20-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	5,247	56.3	27.1
Piping and insulation	287	3.1	1.5
Transport lines	-	-	-
Foundation and structural	314	3.4	1.6
Excavation, site preparation, roads and railroads	183	2.0	0.9
Electrical	1,016	10.9	5.2
Instrumentation	74	0.8	0.4
Buildings	1,004	10.8	5.2
Subtotal	8,125	87.3	41.9
Services and miscellaneous	122	1.3	0.6
Subtotal excluding trucks and equipment	8,247	88.6	42.5
Trucks and earthmoving equipment	1,057	11.4	5.5
Subtotal direct investment	9,304	100.0	48.0
Engineering design and supervision	495	5.3	2.6
Architect and engineering contractor	124	1.3	0.6
Construction expense	1,440	15.6	7.4
Contractor fees	523	5.6	2.7
Subtotal	11,886	127.8	61.3
Contingency	2,377	25.5	12.3
Subtotal fixed investment	14,263	153.3	73.6
Allowance for startup and modifications	1,321	14.2	6.8
Interest during construction	1,712	18.4	8.8
Subtotal capital investment	17,296	185.9	89.2
Land	935	10.0	4.8
Working capital	1,151	12.4	6.0
Total capital investment	19,382	208.3	100.0

a. Basis

Existing 1500-MW plant (20-yr remaining life); 606 klb/hr (60% solids sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities, 60% solids cake.
Land required for disposal, 267 acres at 30 ft deep.
Trucks used for transport of treated sludge to disposal area.
Lime added at 4% of dry solids.

TABLE A-166. IUCS PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 1500-MW plant, 20-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (ground)	49,728 tons	53.00/ton	2,635,600	24.7
Subtotal raw materials cost			2,635,600	24.7
Conversion costs				
Operating labor and supervision				
Plant	43,800 man-hr	12.50/man-hr	547,500	5.1
Solids disposal equipment	87,600 man-hr	17.00/man-hr	1,489,200	14.0
Maintenance--plant labor and material, 4% of direct investment			329,900	3.1
Landfill operation				
Land preparation			22,700	0.2
Trucks (fuel and maintenance)	2,121,000 tons	0.06/ton	127,300	1.2
Earthmoving equipment (fuel and maintenance)	2,121,000 tons	0.16/ton	339,400	3.2
Electricity	9,152 kkWh	0.027/kWh	247,100	2.3
Analyses	1,500 hr	17.00/man-hr	25,500	0.2
Subtotal conversion costs			3,128,600	29.3
Subtotal direct costs			5,764,200	54.0
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 9.3% of total capital investment less land and working capital			1,608,500	15.0
Average cost of capital and taxes at 8.6% of total capital investment			1,666,900	15.6
Overhead				
Plant, 50% of conversion costs less utilities			1,440,800	13.5
Administrative, 10% of operating labor			203,700	1.9
Subtotal indirect costs			4,919,500	46.0
Total annual revenue requirements			10,684,100	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	8.26	5.04	1.02	

a. Basis
Remaining plant life, 20 yr.
Coal burned, 1,314,286 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $19,382,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-167. IUCS PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 1500-MW plant, 15-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	5,247	56.3	27.6
Piping and insulation	287	3.1	1.5
Transport lines	-	-	-
Foundation and structural	314	3.4	1.6
Excavation, site preparation, roads and railroads	183	2.0	1.0
Electrical	1,016	10.9	5.4
Instrumentation	74	0.8	0.4
Buildings	1,004	10.8	5.3
Subtotal	8,125	87.3	42.8
Services and miscellaneous	122	1.3	0.7
Subtotal excluding trucks and equipment	8,247	88.6	43.5
Trucks and earthmoving equipment	1,057	11.4	5.5
Subtotal direct investment	9,304	100.0	49.0
Engineering design and supervision	495	5.3	2.6
Architect and engineering contractor	124	1.3	0.7
Construction expense	1,440	15.6	7.5
Contractor fees	523	5.6	2.8
Subtotal	11,886	127.8	62.6
Contingency	2,377	25.5	12.5
Subtotal fixed investment	14,263	153.3	75.2
Allowance for startup and modifications	1,321	14.2	6.9
Interest during construction	1,712	18.4	9.0
Subtotal capital investment	17,296	185.9	91.1
Land	529	5.7	2.8
Working capital	1,151	12.4	6.1
Total capital investment	18,976	204.0	100.0

[a] Basis
Existing 200-MW plant (15-yr remaining life); 606 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities, 60% solids cake.
Land required for disposal, 151 acres at 30 ft deep.
Trucks used for transport of treated sludge to disposal area.
Lime added at 4% of dry solids.

TABLE A-168. IUCS PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 1500-MW plant, 15-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (ground)	49,728 tons	53.00/ton	2,635,600	24.2
Subtotal raw materials cost			2,635,600	24.2
Conversion costs				
Operating labor and supervision				
Plant	43,800 man-hr	12.50/man-hr	547,500	5.0
Solids disposal equipment	87,600 man-hr	17.00/man-hr	1,489,200	13.6
Maintenance--plant labor and material, 4% of direct investment			329,900	3.0
Landfill operation				
Land preparation			17,100	0.2
Trucks (fuel and maintenance)	2,121,000 tons	0.06/ton	127,300	1.2
Earthmoving equipment (fuel and maintenance)	2,121,000 tons	0.16/ton	339,400	3.1
Electricity	9,152 kkWh	0.027/kWh	247,100	2.3
Analyses	1,500 hr	17.00/man-hr	25,500	0.2
Subtotal conversion costs			3,123,000	28.6
Subtotal direct costs			5,758,600	52.8
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 10.8% of total capital investment less land and working capital			1,868,000	17.1
Average cost of capital and taxes at 8.6% of total capital investment			1,632,000	15.0
Overhead				
Plant, 50% of conversion costs less utilities			1,438,000	13.2
Administrative, 10% of operating labor			203,700	1.9
Subtotal indirect costs			5,141,700	47.2
Total annual revenue requirements			10,900,300	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	8.43	5.14	1.04	

a. Basis
Remaining plant life, 15 yr.
Coal burned, 1,314,286 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $18,876,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-169. IUCS PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: 12% flyash in coal)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,225	51.9	23.9
Piping and insulation	141	3.3	1.5
Transport lines	-	-	-
Foundation and structural	106	2.5	1.1
Excavation, site preparation, roads and railroads	107	2.5	1.1
Electrical	452	10.6	4.8
Instrumentation	66	1.5	0.7
Buildings	550	12.8	5.9
Subtotal	3,647	85.1	39.0
Services and miscellaneous	55	1.3	0.6
Subtotal excluding trucks and equipment	3,702	86.4	39.6
Trucks and earthmoving equipment	581	13.6	6.2
Subtotal direct investment	4,283	100.0	45.8
Engineering design and supervision	334	7.8	3.6
Architect and engineering contractor	84	2.0	0.9
Construction expense	741	17.2	7.9
Contractor fees	290	6.8	3.1
Subtotal	5,732	133.8	61.3
Contingency	1,146	26.8	12.3
Subtotal fixed investment	6,878	160.6	73.6
Allowance for startup and modifications	630	14.7	6.7
Interest during construction	825	19.3	8.9
Subtotal capital investment	8,333	194.6	89.2
Land	557	13.0	5.9
Working capital	455	10.6	4.9
Total capital investment	9,345	218.2	100.0

a. Basis

New 500-MW plant (30-yr life); 163 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 12% ash, 11,100 Btu/lb HV.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities, 60% solids cake.
Land required for disposal, 159 acres at 30 ft deep.
Trucks used for transport of treated sludge to disposal area.
Lime added at 4% of dry solids.

TABLE A-170. IUCS PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 12% ash in coal)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (ground)	13,395 tons	53.00/ton	709,900	15.7
Subtotal raw materials cost			709,900	15.7
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	9.7
Solids disposal equipment	52,560 man-hr	17.00/man-hr	893,500	19.7
Maintenance--plant labor and material, 4% of direct investment			148,100	3.3
Landfill operation				
Land preparation			9,000	0.2
Trucks (fuel and maintenance)	570,500 tons	0.06/ton	34,200	0.7
Earthmoving equipment (fuel and maintenance)	570,500 tons	0.16/ton	91,300	2.0
Electricity	3,000 kkWh	0.029/kWh	87,000	1.9
Analyses	1,000 hr	17.00/man-hr	17,000	0.4
Subtotal conversion costs			1,718,100	37.9
Subtotal direct costs			2,428,000	53.6
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			652,500	14.4
Average cost of capital and taxes at 8.6% of total capital investment			803.700	17.7
Overhead				
Plant, 50% of conversion costs less utilities			515,600	11.4
Administrative, 10% of operating labor			133,200	2.9
Subtotal indirect costs			2,105,000	46.4
Total annual revenue requirements			4,533,000	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	13.05	7.94	1.30	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 405,405 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $9,345,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-171. IUCS PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: 20% flyash in coal)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,886	53.2	24.4
Piping and insulation	192	3.5	1.6
Transport lines	-	-	-
Foundation and structural	141	2.6	1.2
Excavation, site preparation, roads and railroads	118	2.2	1.0
Electrical	704	13.0	5.9
Instrumentation	70	1.3	0.6
Buildings	550	10.1	4.6
Subtotal	4,661	85.9	39.3
Services and miscellaneous	70	1.2	0.6
Subtotal excluding trucks and equipment	4,731	87.1	39.9
Trucks and earthmoving equipment	698	12.9	5.9
Subtotal direct investment	5,429	100.0	45.8
Engineering design and supervision	392	7.2	3.3
Architect and engineering contractor	98	1.8	0.8
Construction expense	908	16.7	7.7
Contractor fees	347	6.4	2.9
Subtotal	7,174	132.1	60.5
Contingency	1,435	26.5	12.1
Subtotal fixed investment	8,609	158.6	72.6
Allowance for startup and modifications	791	14.6	6.7
Interest during construction	1,033	19.0	8.7
Subtotal capital investment	10,433	192.2	88.0
Land	809	14.9	6.8
Working capital	615	11.3	5.2
Total capital investment	11,857	218.4	100.0

a. Basis
New 500-MW plant (30-yr life); 236 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 20% ash, 9,900 Btu/lb HV.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities, 60% solids cake.
Land required for disposal, 231 acres at 30 ft deep.
Trucks used for transport of treated sludge to disposal area.
Lime added at 4% of dry solids.

TABLE A-172. IUCS PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 20% ash in coal)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (ground)	19,376 tons	53.00/ton	1,026,900	17.2
Subtotal raw materials cost			1,026,900	17.2
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	7.3
Solids disposal equipment	61,320 man-hr	17.00/man-hr	1,042,400	17.5
Maintenance--plant labor and material, 4% of direct investment			189,200	3.2
Landfill operation				
Land preparation			13,000	0.2
Trucks (fuel and maintenance)	826,000 tons	0.06/ton	49,600	0.8
Earthmoving equipment (fuel and maintenance)	826,000 tons	0.16/ton	132,200	2.2
Electricity	4,424 kkWh	0.029/kWh	128,300	2.2
Analyses	1,000 hr	17.00/man-hr	17,000	0.3
Subtotal conversion costs			2,009,700	33.7
Subtotal direct costs			3,036,600	50.9
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			816,900	13.7
Average cost of capital and taxes at 8.6% of total capital investment			1,028,300	17.2
Overhead				
Plant, 50% of conversion costs less utilities			940,700	15.7
Administrative, 10% of operating labor			148,000	2.5
Subtotal indirect costs			2,933,900	49.1
Total annual revenue requirements			5,970,500	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	11.84	7.23	1.71

a. Basis
Remaining plant life, 30 yr.
Coal burned, 454,545 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $11,957,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-173. IUCS PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: 2% S content in coal)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,128	50.9	23.4
Piping and insulation	140	3.3	1.5
Transport lines	-	-	-
Foundation and structural	105	2.5	1.2
Excavation, site preparation, roads and railroads	104	2.5	1.1
Electrical	542	12.9	5.9
Instrumentation	58	1.4	0.6
Buildings	550	13.1	6.0
Subtotal	3,627	86.6	39.7
Services and miscellaneous	54	1.3	0.6
Subtotal excluding trucks and equipment	3,681	87.9	40.3
Trucks and earthmoving equipment	505	12.1	5.6
Subtotal direct investment	4,186	100.0	45.9
Engineering design and supervision	334	8.0	3.7
Architect and engineering contractor	84	2.0	0.9
Construction expense	737	17.6	8.1
Contractor fees	285	6.8	3.1
Subtotal	5,626	134.4	61.7
Contingency	1,125	26.9	12.3
Subtotal fixed investment	6,751	161.3	74.0
Allowance for startup and modifications	625	14.9	6.8
Interest during construction	810	19.4	8.9
Subtotal capital investment	8,186	195.6	89.7
Land	469	11.2	5.1
Working capital	470	11.2	5.2
Total capital investment	9,125	218.0	100.0

a. Basis

New 500-MW plant (30-yr life); 137 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 2% S (dry basis), 16% ash, 10,700 Btu/lb HV.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities, 60% solids cake.
Land required for disposal, 193 acres at 30 ft deep.
Trucks used for transport of treated sludge to disposal area.
Lime added at 4% of dry solids.

TABLE A-174. IUCS PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 2% S in coal)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (ground)	11,274 tons	53.00/ton	597,500	12.8
Subtotal raw materials cost			597,500	12.8
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	9.4
Solids disposal equipment	52,560 man-hr	17.00/man-hr	893,500	19.2
Maintenance--plant labor and material, 4% of direct investment			147,200	3.2
Landfill operation				
Land preparation			8,000	0.2
Trucks (fuel and maintenance)	479,500 tons	0.06/ton	28,800	0.6
Earthmoving equipment (fuel and maintenance)	479,500 tons	0.16/ton	76,700	1.6
Electricity	3,172 kkWh	0.029/kWh	92,000	2.0
Analyses	1,000 hr	17.00/man-hr	17,000	0.4
Subtotal conversion costs			1,701,200	36.6
Subtotal direct costs			2,298,700	49.4
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			641,000	13.8
Average cost of capital and taxes at 8.6% of total capital investment			776,200	16.6
Overhead				
Plant, 50% of conversion costs less utilities			804,600	17.3
Administrative, 10% of operating labor			133,200	2.9
Subtotal indirect costs			2,355,000	50.6
Total annual revenue requirements			4,653,700	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	15.57	9.71	1.33	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 420,561 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $9,025,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-175. IUCS PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: 5% S in coal)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	3,078	54.9	25.0
Piping and insulation	186	3.3	1.5
Transport lines	-	-	-
Foundation and structural	147	2.6	1.2
Excavation, site preparation, roads and railroads	122	2.2	1.0
Electrical	691	12.3	5.6
Instrumentation	70	1.2	0.6
Buildings	550	9.8	4.5
Subtotal	4,844	86.3	39.4
Services and miscellaneous	73	1.3	0.6
Subtotal excluding trucks and equipment	4,917	87.6	40.0
Trucks and earthmoving equipment	698	12.4	5.7
Subtotal direct investment	5,615	100.0	45.7
Engineering design and supervision	392	7.0	3.2
Architect and engineering contractor	98	1.7	0.8
Construction expense	938	16.8	7.6
Contractor fees	356	6.3	2.9
Subtotal	7,399	131.8	60.2
Contingency	1,480	26.3	12.1
Subtotal fixed investment	8,879	158.1	72.3
Allowance for startup and modifications	818	14.6	6.6
Interest during construction	1,065	19.0	8.7
Subtotal capital investment	10,762	191.7	87.6
Land	879	15.7	7.2
Working capital	642	11.4	5.2
Total capital investment	12,283	218.8	100.0

[a] Basis
New 500-MW plant (30-yr life); 257 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 5% S (dry basis), 16% ash, 10,400 Btu/lb HV.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities, 60% solids cake.
Land required for disposal, 251 acres at 30 ft deep.
Trucks used for transport of treated sludge to disposal area.
Lime added at 4% of dry solids.

TABLE A-176. IUCS PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 5% S in coal)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (ground)	21,088 tons	53.00/ton	1,117,700	18.1
Subtotal raw materials cost			1,117,700	18.1
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	7.1
Solids disposal equipment	61,320 man-hr	17.00/man-hr	1,042,400	16.8
Maintenance--plant labor and material, 4% of direct investment			224,600	3.6
Landfill operation				
Land preparation			14,000	0.2
Trucks (fuel and maintenance)	889,500 tons	0.06/ton	53,400	0.9
Earthmoving equipment (fuel and maintenance)	889,500 tons	0.16/ton	142,300	2.3
Electricity	4,320 kkWh	0.029/kWh	125,300	2.0
Analyses	1,000 hr	17.00/man-hr	17,000	0.3
Subtotal conversion costs			2,057,000	33.2
Subtotal direct costs			3,174,700	51.3
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			842,700	13.6
Average cost of capital and taxes at 8.6% of total capital investment			1,056,300	17.1
Overhead				
Plant, 50% of conversion costs less utilities			965,900	15.6
Administrative, 10% of operating labor			148,000	2.4
Subtotal indirect costs			3,012,900	48.7
Total annual revenue requirements			6,187,600	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	11.29	6.88	1.77	

[a] Basis
Remaining plant life, 30 yr.
Coal burned, 432,692 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $12,283,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-177. IUCS PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: 200 MW with flyash removed independently of SO_2)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	1,435	43.4	19.6
Piping and insulation	114	3.4	1.6
Transport lines	-	-	-
Foundation and structural	95	2.9	1.3
Excavation, site preparation, roads and railroads	89	2.7	1.2
Electrical	581	17.5	8.0
Instrumentation	64	1.9	0.9
Buildings	550	16.6	7.5
Subtotal	2,928	88.4	40.1
Services and miscellaneous	44	1.3	0.6
Subtotal excluding trucks and equipment	2,972	89.7	40.7
Trucks and earthmoving equipment	340	10.3	4.7
Subtotal direct investment	3,312	100.0	45.4
Engineering design and supervision	392	11.8	5.4
Architect and engineering contractor	98	3.0	1.3
Construction expense	617	18.6	8.4
Contractor fees	239	7.2	3.3
Subtotal	4,658	140.6	63.8
Contingency	932	28.2	12.7
Subtotal fixed investment	5,590	168.8	76.5
Allowance for startup and modifications	525	15.9	7.2
Interest during construction	671	20.2	9.2
Subtotal capital investment	6,786	204.9	92.9
Land	203	6.1	2.8
Working capital	312	9.4	4.3
Total capital investment	7,301	220.4	100.0

[a] Basis
New 200-MW plant (30-yr life); 59 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed independently of SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities, 60% solids cake.
Land required for disposal, 59 acres at 30 ft deep.
Trucks used for transport of treated sludge to disposal area.
Lime and flyash added at 4% of dry solids.

TABLE A-178. IUCS PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 200-MW plant)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (ground)	3,518 tons	53.00/ton	186,500	5.5
Subtotal raw materials cost			186,500	5.5
Conversion costs				
Operating labor and supervision				
Plant	26,280 man-hr	12.50/man-hr	328,500	9.7
Solids disposal equipment	43,800 man-hr	17.00/man-hr	744,600	21.8
Maintenance--plant labor and material, 4% of direct investment			118,900	3.5
Landfill operation				
Land preparation			3,000	0.1
Trucks (fuel and maintenance)	206,500 tons	0.06/ton	12,400	0.4
Earthmoving equipment (fuel and maintenance)	206,500 tons	0.16/ton	33,000	1.0
Electricity	1,834 kkWh	0.031/kWh	56,900	1.7
Analyses	1,000 hr	17.00/man-hr	17,000	0.5
Subtotal conversion costs			1,314,300	38.7
Subtotal direct costs			1,500,800	44.2
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			531,300	15.6
Average cost of capital and taxes at 8.6% of total capital investment			627,900	18.5
Overhead				
Plant, 50% of conversion costs less utilities			628,700	18.5
Administrative, 10% of operating labor			107,300	3.2
Subtotal indirect costs			1,895,200	55.8
Total annual revenue requirements			3,396,000	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	37.03	16.45	2.43	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 175,238 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $7,301,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-179. IUCS PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: flyash removed independently of SO_2)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,230	49.6	22.6
Piping and insulation	141	3.1	1.4
Transport lines	-	-	-
Foundation and structural	154	3.4	1.6
Excavation, site preparation, roads and railroads	99	2.2	1.0
Electrical	763	16.9	7.8
Instrumentation	66	1.5	0.7
Buildings	550	12.2	5.6
Subtotal	4,003	88.9	40.7
Services and miscellaneous	60	1.3	0.6
Subtotal excluding trucks and equipment	4,063	90.2	41.3
Trucks and earthmoving equipment	441	9.8	4.5
Subtotal direct investment	4,504	100.0	45.8
Engineering design and supervision	403	8.9	4.1
Architect and engineering contractor	101	2.2	1.0
Construction expense	800	17.8	8.1
Contractor fees	301	6.7	3.1
Subtotal	6,109	135.6	62.1
Contingency	1,222	27.2	12.4
Subtotal fixed investment	7,331	162.8	74.5
Allowance for startup and modifications	689	15.3	7.0
Interest during construction	880	19.5	9.0
Subtotal capital investment	8,900	197.6	90.5
Land	494	11.0	5.0
Working capital	445	9.9	4.5
Total capital investment	9,839	218.5	100.0

a. Basis

New 500-MW plant (30-yr life); 144 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed independently of SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities, 60% solids cake.
Land required for disposal, 141 acres at 30 ft deep.
Trucks used for transport of treated sludge to disposal area.
Lime and flyash both added at 4% of dry solids.

TABLE A-180. IUCS PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: no flyash)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (ground)	8,600 tons	53.00/ton	455,800	9.8
Subtotal raw materials cost			455,800	9.8
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	9.4
Solids disposal equipment	52,560 man-hr	17.00/man-hr	893,500	19.3
Maintenance--plant labor and material, 4% of direct investment			161,700	3.4
Landfill operation				
Land preparation			8,000	0.2
Trucks (fuel and maintenance)	504,000 tons	0.06/ton	30,200	0.6
Earthmoving equipment (fuel and maintenance)	504,000 tons	0.16/ton	80,600	1.7
Electricity	2,577 kkWh	0.029/kWh	74,700	1.6
Analyses	1,000 hr	17.00/man-hr	17,000	0.4
Subtotal conversion costs			1,703,700	36.6
Subtotal direct costs			2,159,500	46.4
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			696,900	15.0
Average cost of capital and taxes at 8.6% of total capital investment			846,200	18.2
Overhead				
Plant, 50% of conversion costs less utilities			814,500	17.5
Administrative, 10% of operating labor			133,200	2.9
Subtotal indirect costs			2,490,800	53.6
Total annual revenue requirements			4,650,300	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	20.87	9.23	1.33

a. Basis

Remaining plant life, 30 yr.
Coal burned, 482,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $9,839,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-181. IUCS PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: 1500-MW plant, flyash removed independently of SO_2)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	4,422	53.0	24.6
Piping and insulation	202	2.4	1.1
Transport lines	-	-	-
Foundation and structural	359	4.3	2.0
Excavation, site preparation, roads and railroads	135	1.6	0.7
Electrical	1,274	15.3	7.0
Instrumentation	73	0.9	0.4
Buildings	1,004	12.0	5.5
Subtotal	7,469	89.5	41.3
Services and miscellaneous	112	1.3	0.6
Subtotal excluding pond	7,581	90.8	41.9
Pond construction	766	9.2	4.2
Subtotal direct investment	8,347	100.0	46.1
Engineering design and supervision	587	7.0	3.2
Architect and engineering contractor	147	1.8	0.8
Construction expense	1,343	16.1	7.4
Contractor fees	482	5.8	2.7
Subtotal	10,906	130.7	60.2
Contingency	2,181	26.1	12.1
Subtotal fixed investment	13,087	156.8	72.3
Allowance for startup and modifications	1,232	14.8	6.8
Interest during construction	1,570	18.8	8.7
Subtotal capital investment	15,889	190.4	87.8
Land	1,414	16.9	7.8
Working capital	800	9.6	4.4
Total capital investment	18,103	216.9	100.0

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a. Basis

New 1500-MW plant (30-yr life); 430 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed independently of SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities, 60% solids cake.
Land required for disposal, 404 acres at 30 ft deep.
Trucks used for transport of treated sludge to disposal area.
Lime and flyash both added at 4% of dry solids.

TABLE A-182. IUCS PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 1500-MW plant)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (ground)	25,799 tons	53.00/ton	1,367,300	16.8
Subtotal raw materials cost			1,367,300	16.8
Conversion costs				
Operating labor and supervision				
Plant	43,800 man-hr	12.50/man-hr	547,500	6.7
Solids disposal equipment	70,080 man-hr	17.00/man-hr	1,191,400	14.6
Maintenance--plant labor and material, 4% of direct investment			313,400	3.8
Landfill operation				
Land preparation			23,000	0.3
Trucks (fuel and maintenance)	1,505,000 tons	0.06/ton	90,300	1.1
Earthmoving equipment (fuel and maintenance)	1,505,000 tons	0.16/ton	240,800	3.0
Electricity	6,356 kkWh	0.027/kWh	171,600	2.1
Analyses	1,500 hr	17.00/man-hr	25,500	0.3
Subtotal conversion costs			2,603,500	31.9
Subtotal direct costs			3,970,800	48.7
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			1,244,100	15.2
Average cost of capital and taxes at 8.6% of total capital investment			1,556,900	19.1
Overhead				
Plant, 50% of conversion costs less utilities			1,216,000	14.9
Administrative, 10% of operating labor			173,900	2.1
Subtotal indirect costs			4,190,900	51.3
Total annual revenue requirements			8,161,700	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	12.17	5.42	0.78

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a. Basis

Remaining plant life, 30 yr.
Coal burned, 1,285,714 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $18,103,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-183. IUCS PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: truck 5 mi to disposal)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,551	48.8	22.5
Piping and insulation	176	3.4	1.5
Transport lines	-	-	-
Foundation and structural	136	2.6	1.2
Excavation, site preparation, roads and railroads	115	2.2	1.0
Electrical	650	12.4	5.7
Instrumentation	70	1.3	0.6
Buildings	550	10.5	4.8
Subtotal	4,248	81.2	37.3
Services and miscellaneous	64	1.2	0.6
Subtotal excluding trucks and equipment	4,312	82.4	37.9
Trucks and earthmoving equipment	923	17.6	8.1
Subtotal direct investment	5,235	100.0	46.0
Engineering design and supervision	392	7.5	3.4
Architect and engineering contractor	98	1.9	0.9
Construction expense	841	16.0	7.4
Contractor fees	338	6.5	3.0
Subtotal	6,904	131.9	60.7
Contingency	1,381	26.4	12.1
Subtotal fixed investment	8,285	158.3	72.8
Allowance for startup and modifications	736	14.1	6.5
Interest during construction	994	18.9	8.7
Subtotal capital investment	10,015	191.3	88.0
Land	676	12.9	6.0
Working capital	686	13.1	6.0
Total capital investment	11,377	217.3	100.0

[a] Basis

New 500-MW plant (30-yr life); 198 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 5 mi from scrubber facilities, 60% solids cake.
Land required for disposal, 193 acres at 30 ft deep.
Trucks used for transport of treated sludge to disposal area.
Lime added at 4% of dry solids.

TABLE A-184. IUCS PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: disposal area 5 mi from scrubber facilities)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (ground)	16,216 tons	53.00/ton	859,400	13.2
Subtotal raw materials cost			859,400	13.2
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	439,800	6.8
Solids disposal equipment	87,600 man-hr	17.00/man-hr	1,489,200	22.9
Maintenance--plant labor and material, 4% of direct investment			172,500	2.7
Landfill operation				
Land preparation			11,000	0.2
Trucks (fuel and maintenance)	693,000 tons	0.20/ton	138,600	2.1
Earthmoving equipment (fuel and maintenance)	693,000 tons	0.16/ton	110,900	1.7
Electricity	3,688 kkWh	0.029/kWh	107,000	1.6
Analyses	1,000 hr	17.00/man-hr	17,000	0.3
Subtotal conversion costs			2,486,000	38.3
Subtotal direct costs			3,345,400	51.5
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			784,200	12.1
Average cost of capital and taxes at 8.6% of total capital investment			978,400	15.1
Overhead				
Plant, 50% of conversion costs less utilities			1,189,500	18.3
Administrative, 10% of operating labor			192,900	3.0
Subtotal indirect costs			3,145,000	48.5
Total annual revenue requirements			6,490,400	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	15.40	9.37	1.85

a. Basis
Remaining plant life, 30 yr.
Coal burned, 482,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $11,377,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-185. IUCS PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: truck 10 mi to disposal)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,551	46.2	21.4
Piping and insulation	176	3.2	1.5
Transport lines	-	-	-
Foundation and structural	136	2.5	1.1
Excavation, site preparation, roads and railroads	115	2.1	1.0
Electrical	650	11.8	5.5
Instrumentation	70	1.3	0.6
Buildings	550	10.0	4.6
Subtotal	4,248	77.1	35.7
Services and miscellaneous	64	1.2	0.6
Subtotal excluding trucks and equipment	4,312	78.3	36.3
Trucks and earthmoving equipment	1,197	21.7	10.0
Subtotal direct investment	5,509	100.0	46.3
Engineering design and supervision	392	7.1	3.3
Architect and engineering contractor	98	1.8	0.8
Construction expense	841	15.2	7.1
Contractor fees	351	6.4	3.0
Subtotal	7,191	130.5	60.5
Contingency	1,438	26.1	12.1
Subtotal fixed investment	8,629	156.6	72.6
Allowance for startup and modifications	743	13.5	6.2
Interest during construction	1,035	18.8	8.7
Subtotal capital investment	10,407	188.9	87.5
Land	676	12.3	5.7
Working capital	808	14.6	6.8
Total capital investment	11,891	215.8	100.0

[a] Basis
New 500-MW plant (30-yr life); 198 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 10 mi from scrubber facilities, 60% solids cake.
Land required for disposal, 198 acres at 30 ft deep.
Trucks used for transport of treated sludge to disposal area.
Lime added at 4% of dry solids.

TABLE A-186. IUCS PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: disposal area 10 mi from scrubber facilities)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (ground)	16,216 tons	53.00/ton	859,500	11.5
Subtotal raw materials cost			859,500	11.5
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	5.9
Solids disposal equipment	113,880 man-hr	17.00/man-hr	1,936,000	25.9
Maintenance--plant labor and material, 4% of direct investment			172,500	2.3
Landfill operation				
Land preparation			11,000	3.6
Trucks (fuel and maintenance)	693,000 tons	0.39/ton	270,300	3.6
Earthmoving equipment (fuel and maintenance)	693,000 tons	0.16/ton	110,900	1.5
Electricity	3,688 kkWh	0.029/kWh	107,000	1.4
Analyses	1,000 hr	17.00/man-hr	17,000	0.2
Subtotal conversion costs			3,062,700	41.0
Sub[illegible]al direct costs			3,922,200	52.5
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			814,900	10.9
Average cost of capital and taxes at 8.6% of total capital investment			1,022,600	13.7
Overhead				
Plant, 50% of conversion costs less utilities			1,477,900	19.7
Administrative, 10% of operating labor			237,400	3.2
Subtotal indirect costs			3,552,800	47.5
Total annual revenue requirements			7,475,000	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	17.73	10.78	2.14	

a. Basis

Remaining plant life, 30 yr.
Coal burned, 482,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $11,891,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-187. IUCS PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: lime added for stabilization at 5% of dry solids rate)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,584	52.6	23.8
Piping and insulation	176	3.6	1.6
Transport lines	-	-	-
Foundation and structural	137	2.8	1.3
Excavation, site preparation, roads and railroads	115	2.3	1.1
Electrical	639	13.0	5.9
Instrumentation	70	1.4	0.6
Buildings	550	11.2	5.1
Subtotal	4,271	86.9	39.4
Services and miscellaneous	63	1.3	0.6
Subtotal excluding trucks and equipment	4,334	88.2	40.0
Trucks and earthmoving equipment	581	11.8	5.3
Subtotal direct investment	4,915	100.0	45.3
Engineering design and supervision	449	9.3	4.1
Architect and engineering contractor	112	2.3	1.0
Construction expense	828	17.2	7.7
Contractor fees	317	6.6	2.9
Subtotal	6,621	135.4	61.0
Contingency	1,304	27.1	12.1
Subtotal fixed investment	7,925	162.5	73.1
Allowance for startup and modifications	725	15.1	6.7
Interest during construction	939	19.5	8.6
Subtotal capital investment	9,589	197.1	88.4
Land	679	13.8	6.3
Working capital	579	11.8	5.3
Total capital investment	10,847	220.7	100.0

a. Basis
New 500-MW plant (30-yr life); 199 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities, 60% solids cake.
Land required for disposal, 194 acres at 30 ft deep.
Trucks used for transport of treated sludge to disposal area.
Lime added at 5% of dry solids.

TABLE A-188. IUCS PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 5% lime, solid, added to mixing bin)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (ground)	20,269 tons	53.00/ton	1,074,300	19.5
Subtotal raw materials cost			1,074,300	19.5
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	8.0
Solids disposal equipment	52,560 man-hr	17.00/man-hr	893,500	16.2
Maintenance--plant labor and material, 4% of direct investment			169,400	3.1
Landfill operation				
Land preparation			11,000	0.2
Trucks (fuel and maintenance)	696,500 tons	0.06/ton	41,800	0.8
Earthmoving equipment (fuel and maintenance)	696,500 tons	0.16/ton	111,400	2.0
Electricity	3,890 kkWh	0.029/kWh	112,800	2.0
Analyses	1,000 hr	17.00/man-hr	17,000	0.3
Subtotal conversion costs			1,794,900	32.6
Subtotal direct costs			2,869,200	52.1
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			743,100	13.5
Average cost of capital and taxes at 8.6% of total capital investment			924,300	16.7
Overhead				
Plant, 50% of conversion costs less utilities			841,100	15.3
Administrative, 10% of operating labor			133,200	2.4
Subtotal indirect costs			2,641,700	47.9
Total annual revenue requirements			5,510,900	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	12.95	7.91	1.57	

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a. Basis

Remaining plant life, 30 yr.

Coal burned, 482,571 lb/hr, 9,000 Btu/kWh.

Power plant on-stream time, 7,000 hr/yr.

Total capital investment, $10,748,000.

Midwest plant location, mid-1980 operating costs.

TABLE A-189. IUCS PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: lime added for stabilization at 3% of dry solid rate)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,479	52.7	24.1
Piping and insulation	176	3.7	1.7
Transport lines	-	-	-
Foundation and structural	109	2.3	1.1
Excavation, site preparation, roads and railroads	114	2.4	1.1
Electrical	575	12.2	5.6
Instrumentation	66	1.4	0.6
Buildings	550	11.7	5.3
Subtotal	4,069	86.4	39.5
Services and miscellaneous	61	1.3	0.6
Subtotal excluding trucks and equipment	4,130	87.7	40.1
Trucks and earthmoving equipment	581	12.3	5.6
Subtotal direct investment	4,711	100.0	45.7
Engineering design and supervision	357	7.6	3.5
Architect and engineering contractor	89	1.9	0.9
Construction expense	811	17.2	7.8
Contractor fees	312	6.6	3.0
Subtotal	6,280	133.3	60.9
Contingency	1,256	26.7	12.2
Subtotal fixed investment	7,536	160.0	73.1
Allowance for startup and modifications	696	14.8	6.8
Interest during construction	908	19.1	8.8
Subtotal capital investment	9,140	194.0	88.7
Land	672	14.3	6.5
Working capital	494	10.5	4.8
Total capital investment	10,306	218.8	100.0

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[a] Basis

New 500-MW plant (30-yr life); 196 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities, 60% solids cake.
Land required for disposal, 192 acres at 30 ft deep.
Trucks used for transport of treated sludge to disposal area.
Lime added at 3% of dry solids.

TABLE A-190. IUCS PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 3% lime--solid--added to mixing bin)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (ground)	12,163 tons	53.00/ton	644,600	12.9
Subtotal raw materials cost			644,600	12.9
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	8.8
Solids disposal equipment	52,560 man-hr	17.00/man-hr	893,500	17.9
Maintenance--plant labor and material, 4% of direct investment			165,200	3.3
Landfill operation				
Land preparation			11,000	0.2
Trucks (fuel and maintenance)	686,000 tons	0.06/ton	41,200	0.8
Earthmoving equipment (fuel and maintenance)	686,000 tons	0.16/ton	109,800	2.2
Electricity	3,484 kkWh	0.029/kWh	101,000	2.0
Analyses	1,000 hr	17.00/man-hr	17,000	0.4
Subtotal conversion costs			1,776,700	35.6
Subtotal direct costs			2,421,300	48.5
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			715,300	14.3
Average cost of capital and taxes at 8.6% of total capital investment			886,000	17.7
Overhead				
Plant, 50% of conversion costs less utilities			837,900	16.8
Administrative, 10% of operating labor			133,200	2.7
Subtotal indirect costs			2,572,400	51.5
Total annual revenue requirements			4,993,700	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	11.96	7.28	1.43	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 482,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $10,302,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-191. IUCS PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: lime process with 1.1 stoichiometry)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,499	52.4	24.1
Piping and insulation	168	3.5	1.6
Transport lines	-	-	-
Foundation and structural	137	2.9	1.3
Excavation, site preparation, roads and railroads	120	2.5	1.1
Electrical	587	12.3	5.7
Instrumentation	66	1.4	0.6
Buildings	550	11.5	5.3
Subtotal	4,127	86.5	39.7
Services and miscellaneous	62	1.3	0.6
Subtotal excluding trucks and equipment	4,189	87.8	40.3
Trucks and earthmoving equipment	581	12.2	5.6
Subtotal direct investment	4,770	100.0	45.9
Engineering design and supervision	380	8.0	3.7
Architect and engineering contractor	95	2.0	0.9
Construction expense	821	17.2	7.9
Contractor fees	315	6.6	3.0
Subtotal	6,381	133.8	61.4
Contingency	1,276	26.7	12.3
Subtotal fixed investment	7,657	160.5	73.7
Allowance for startup and modifications	708	14.8	6.8
Interest during construction	919	19.3	8.9
Subtotal capital investment	9,284	194.6	89.4
Land	588	12.4	5.7
Working capital	511	10.7	4.9
Total capital investment	10,383	217.7	100.0

[a] Basis
New 500-MW plant (30-yr life); 172 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Lime process with 1.1 stoichiometry based on SO_2 removed. Scrubber effluent (10% solids).
Disposal in landfill 1 mi from scrubber facilities, 60% solids cake.
Land required for disposal, 168 acres at 30 ft deep.
Trucks used for transport of treated sludge to disposal area.
Lime added at 4% of dry solids.

TABLE A-192. IUCS PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: lime process with 1.1 stoichiometry)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Lime (ground)	14,116 tons	53.00/ton	748,100	14.7
Subtotal raw materials cost			748,100	14.7
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	8.6
Solids disposal equipment	52,560 man-hr	17.00/man-hr	893,500	17.5
Maintenance--plant labor and material, 4% of direct investment			167,600	3.3
Landfill operation				
Land preparation			10,000	0.2
Trucks (fuel and maintenance)	602,000 tons	0.06/ton	36,100	0.7
Earthmoving equipment (fuel and maintenance)	602,000 tons	0.16/ton	96,300	1.9
Electricity	3,600 kkWh	0.029/kWh	104,400	2.1
Analyses	1,000 hr	17.00/man-hr	17,000	0.3
Subtotal conversion costs			1,762,900	34.6
Subtotal direct costs			2,511,000	49.3
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			726,900	14.3
Average cost of capital and taxes at 8.6% of total capital investment			892,900	17.5
Overhead				
Plant, 50% of conversion costs less utilities			829,300	16.3
Administrative, 10% of operating labor			133,200	2.6
Subtotal indirect costs			2,582,300	50.7
Total annual revenue requirements			5,093,300	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	13.88	8.46	1.46

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a. Basis
Remaining plant life, 30 yr.
Coal burned, 482,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $10,383,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-193. CHEMFIX PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Base case)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,885	46.5	21.3
Piping and insulation	227	3.6	1.7
Transport lines	697	11.2	5.2
Foundation and structural	209	3.4	1.5
Excavation, site preparation, roads and railroads	162	2.6	1.2
Electrical	853	13.7	6.3
Instrumentation	107	1.7	0.8
Buildings	550	8.8	4.1
Subtotal	5,690	91.5	42.1
Services and miscellaneous	85	1.4	0.6
Subtotal excluding trucks and equipment	5,775	92.9	42.7
Trucks and earthmoving equipment	442	7.1	3.2
Subtotal direct investment	6,217	100.0	45.9
Engineering design and supervision	472	7.6	3.5
Architect and engineering contractor	118	1.9	0.9
Construction expense	1,072	17.2	8.0
Contractor fees	385	6.2	2.8
Subtotal	8,264	132.9	61.1
Contingency	1,653	26.6	12.2
Subtotal fixed investment	9,917	159.5	73.3
Allowance for startup and modifications	948	15.2	7.0
Interest during construction	1,190	19.2	8.8
Subtotal capital investment	12,055	193.9	89.1
Land	693	11.1	5.1
Working capital	783	12.6	5.8
Total capital investment	13,531	217.6	100.0

a. Basis

New 500-MW plant (30-yr life); 203 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities.
Land required for disposal, 198 acres at 30 ft deep.
Clarified sludge (35% solids) transported by pipeline to disposal/treatment area.
Fixation additives (% of dry solids): Portland cement - 7%, sodium silicate - 4%.

TABLE A-194. CHEMFIX PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Base case)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Sodium silicate (38% soln)	7,357 tons	98.00/ton	721,000	10.3
Cement	28,000 tons	52.00/ton	1,456,000	20.9
Subtotal raw materials cost			2,177,000	31.2
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	6.3
Solids disposal equipment	43,800 man-hr	17.00/man-hr	744,600	10.7
Maintenance--plant labor and material, 4% of direct investment			231,000	3.3
Landfill operation				
Land preparation			11,000	0.1
Trucks (fuel and maintenance)				
Earthmoving equipment (fuel and maintenance)	710,500 tons	0.30/ton	213,200	3.0
Electricity	3,551 kkWh	0.029/kWh	103,000	1.5
Analyses	1,000 hr	17.00/man-hr	17,000	0.2
Subtotal conversion costs			1,757,800	25.1
Subtotal direct costs			3,934,800	56.3
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			943,900	13.5
Average cost of capital and taxes at 8.6% of total capital investment			1,163,700	16.7
Overhead				
Plant, 50% of conversion costs less utilities			827,400	11.8
Administrative, 10% of operating labor			118,300	1.7
Subtotal indirect costs			3,053,300	43.7
Total annual revenue requirements			6,988,100	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	16.51	10.08	2.00

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a. Basis
Remaining plant life, 30 yr.
Coal burned, 428,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $13,531,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-195. CHEMFIX PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: 200-MW plant)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	1,709	39.9	18.6
Piping and insulation	173	4.0	1.9
Transport lines	487	11.4	5.3
Foundation and structural	77	1.8	0.8
Excavation, site preparation, roads and railroads	138	3.2	1.5
Electrical	587	13.7	6.3
Instrumentation	87	2.0	0.9
Buildings	550	12.8	5.9
Subtotal	3,808	88.8	41.2
Services and miscellaneous	57	1.3	0.6
Subtotal excluding trucks and equipment	3,865	90.1	41.8
Trucks and earthmoving equipment	423	9.9	4.6
Subtotal direct investment	4,288	100.0	46.4
Engineering design and supervision	392	9.1	4.2
Architect and engineering contractor	98	2.3	1.1
Construction expense	768	17.9	8.3
Contractor fees	290	6.8	3.1
Subtotal	5,836	136.1	63.1
Contingency	1,167	27.2	12.6
Subtotal fixed investment	7,003	163.3	75.7
Allowance for startup and modifications	658	15.3	7.1
Interest during construction	840	19.7	9.1
Subtotal capital investment	8,501	198.3	91.9
Land	284	6.6	3.1
Working capital	464	10.8	5.0
Total capital investment	9,249	215.7	100.0

a. Basis
New 200-MW plant (30-yr life); 83 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities.
Land required for disposal, 81 acres at 30 ft deep.
Clarified sludge (35% solids) transported by pipeline to disposal/treatment area.
Fixation additives (% of dry solids): Portland cement - 7%, sodium silicate - 4%.

TABLE A-196. CHEMFIX PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 200-MW plant)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Sodium silicate (38% soln)	3,010 tons	98.00/ton	295,000	6.5
Cement	11,431 tons	52.00/ton	594,400	13.1
Subtotal raw materials cost			889,400	19.6
Conversion costs				
Operating labor and supervision				
Plant	26,280 man-hr	12.50/man-hr	328,500	7.3
Solids disposal equipment	43,800 man-hr	17.00/man-hr	744,600	16.5
Maintenance--plant labor and material, 4% of direct investment			154,600	3.4
Landfill operation				
Land preparation			5,000	0.1
Trucks (fuel and maintenance)				
Earthmoving equipment (fuel and maintenance)	290,500 tons	0.30/ton	87,200	1.9
Electricity	2,097 kkWh	0.031/kWh	65,000	1.4
Analyses	1,000 hr	17.00/man-hr	17,000	0.4
Subtotal conversion costs			1,401,900	31.0
Subtotal direct costs			2,291,300	50.6
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			665,600	14.7
Average cost of capital and taxes at 8.6% of total capital investment			796,300	17.6
Overhead				
Plant, 50% of conversion costs less utilities			668,500	14.7
Administrative, 10% of operating labor			107,300	2.4
Subtotal indirect costs			2,237,700	49.4
Total annual revenue requirements			4,529,000	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	26.14	15.59	3.24

a. Basis

Remaining plant life, 30 yr.
Coal burned, 175,238 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $9,259,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-197. CHEMFIX PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 200-MW plant, 25-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	1,836	41.4	19.4
Piping and insulation	175	3.9	1.9
Transport lines	487	11.0	5.2
Foundation and structural	78	1.8	0.8
Excavation, site preparation, roads and railroads	143	3.2	1.5
Electrical	596	13.4	6.3
Instrumentation	87	2.0	0.9
Buildings	550	12.4	5.8
Subtotal	3,952	89.1	41.8
Services and miscellaneous	59	1.4	0.6
Subtotal excluding trucks and equipment	4,011	90.5	42.4
Trucks and earthmoving equipment	423	9.5	4.5
Subtotal direct investment	4,434	100.0	46.9
Engineering design and supervision	392	8.8	4.2
Architect and engineering contractor	98	2.2	1.0
Construction expense	792	17.9	8.4
Contractor fees	298	6.7	3.2
Subtotal	6,014	135.6	63.7
Contingency	1,203	27.2	12.7
Subtotal fixed investment	7,217	162.8	76.4
Allowance for startup and modifications	679	15.3	7.2
Interest during construction	866	19.5	9.1
Subtotal capital investment	8,762	197.6	92.7
Land	214	4.8	2.3
Working capital	472	10.7	5.0
Total capital investment	9,448	213.1	100.0

a. Basis

Existing 200-MW plant (25-yr remaining life); 86 klb/hr (60% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities.
Land required for disposal, 61 acres at 30 ft deep.
Clarified sludge (35% solids) transported by pipeline to disposal/treatment area.
Fixation additives (% of dry solids): Portland cement - 7%, sodium silicate - 4%.

TABLE A-198. CHEMFIX PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 200-MW plant, 25-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Sodium silicate (38% soln)	3,115 tons	98.00/ton	305,300	6.5
Cement	11,806 tons	52.00/ton	613,900	13.1
Subtotal raw materials cost			919,200	19.6
Conversion costs				
Operating labor and supervision				
Plant	26,280 man-hr	12.50/man-hr	328,500	7.0
Solids disposal equipment	43,800 man-hr	17.00/man-hr	744,600	15.9
Maintenance--plant labor and material, 4% of direct investment			160,400	3.4
Landfill operation				
Land preparation			4,100	0.1
Trucks (fuel and maintenance)				
Earthmoving equipment (fuel and maintenance)	301,000 tons	0.30/ton	90,300	1.9
Electricity	2,175 kkWh	0.031/kWh	67,400	1.4
Analyses	1,000 hr	17.00/man-hr	17,000	0.4
Subtotal conversion costs			1,412,300	30.1
Subtotal direct costs			2,331,500	49.7
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 8.8% of total capital investment less land and working capital			771,100	16.4
Average cost of capital and taxes at 8.6% of total capital investment			812,500	17.3
Overhead				
Plant, 50% of conversion costs less utilities			672,500	14.3
Administrative, 10% of operating labor			107,300	2.3
Subtotal indirect costs			2,363,400	50.3
Total annual revenue requirements			4,694,900	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	26.11	15.60	3.35	

a. Basis
Remaining plant life, 25 yr.
Coal burned, 180,952 lb/hr, 9,500 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $9,448,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-199. CHEMFIX PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 200-MW plant, 20-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	1,836	41.4	19.6
Piping and insulation	175	3.9	1.9
Transport lines	487	11.0	5.2
Foundation and structural	78	1.8	0.8
Excavation, site preparation, roads and railroads	143	3.2	1.5
Electrical	596	13.4	6.4
Instrumentation	87	2.0	0.9
Buildings	550	12.4	5.9
Subtotal	3,952	89.1	42.2
Services and miscellaneous	59	1.4	0.6
Subtotal excluding trucks and equipment	4,011	90.5	42.8
Trucks and earthmoving equipment	423	9.5	4.5
Subtotal direct investment	4,434	100.0	47.3
Engineering design and supervision	392	8.8	4.2
Architect and engineering contractor	98	2.2	1.0
Construction expense	792	17.9	8.5
Contractor fees	298	6.7	3.2
Subtotal	6,014	135.6	64.2
Contingency	1,203	27.2	12.8
Subtotal fixed investment	7,217	162.8	77.0
Allowance for startup and modifications	679	15.3	7.2
Interest during construction	866	19.5	9.3
Subtotal capital investment	8,762	197.6	93.5
Land	133	3.0	1.4
Working capital	472	10.7	5.1
Total capital investment	9,367	211.3	100.0

[a] Basis

Existing 200-MW plant (20-yr remaining life); 86 klb/hr (60% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979.

Coal analysis (by wt): 3.5% S (dry basis), 16% ash.

Flyash removed with SO_2.

SO_2 and flyash removed to meet NSPS.

Limestone process with 1.5 stoichiometry based on SO_2 removed.

Disposal in landfill 1 mi from scrubber facilities.

Land required for disposal, 38 acres at 30 ft deep.

Clarified sludge (35% solids) transported by pipeline to disposal/treatment area.

Fixation additives (% of dry solids): Portland cement - 7%, sodium silicate - 4%.

TABLE A-200. CHEMFIX PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 200-MW plant, 20-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Sodium silicate (38% soln)	3,115 tons	98.00/ton	305,300	6.5
Cement	11,806 tons	52.00/ton	613,900	13.0
Subtotal raw materials cost			919,200	19.5
Conversion costs				
Operating labor and supervision				
Plant	26,280 man-hr	12.50/man-hr	328,500	6.9
Solids disposal equipment	43,800 man-hr	17.00/man-hr	744,600	15.7
Maintenance--plant labor and material, 4% of direct investment			160,400	3.4
Landfill operation				
Land preparation			3,200	0.1
Trucks (fuel and maintenance)				
Earthmoving equipment (fuel and maintenance)	301,000 tons	0.30/ton	90,300	1.9
Electricity	2,175 kkWh	0.031/kWh	67,400	1.4
Analyses	1,000 hr	17.00/man-hr	17,000	0.4
Subtotal conversion costs			1,411,400	29.8
Subtotal direct costs			2,330,600	49.3
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 9.3% of total capital investment less land and working capital			814,900	17.2
Average cost of capital and taxes at 8.6% of total capital investment			805,600	17.0
Overhead				
Plant, 50% of conversion costs less utilities			672,000	14.2
Administrative, 10% of operating labor			107,300	2.3
Subtotal indirect costs			2,399,800	50.7
Total annual revenue requirements			4,730,400	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	26.31	15.72	3.38	

a. Basis
Remaining plant life, 20 yr.
Coal burned, 180,952 lb/hr, 9,500 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $9,367,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-201. CHEMFIX PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 200-MW plant, 15-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	1,836	41.4	19.8
Piping and insulation	175	4.0	1.9
Transport lines	487	11.0	5.2
Foundation and structural	78	1.8	0.8
Excavation, site preparation, roads and railroads	143	3.2	1.5
Electrical	596	13.4	6.4
Instrumentation	87	2.0	0.9
Buildings	550	12.4	5.9
Subtotal	3,952	89.2	42.4
Services and miscellaneous	59	1.3	0.7
Subtotal excluding trucks and equipment	4,011	90.5	43.1
Trucks and earthmoving equipment	423	9.5	4.5
Subtotal direct investment	4,434	100.0	47.6
Engineering design and supervision	392	8.8	4.2
Architect and engineering contractor	98	2.2	1.1
Construction expense	792	17.9	8.5
Contractor fees	298	6.7	3.2
Subtotal	6,014	135.6	64.6
Contingency	1,203	27.2	12.9
Subtotal fixed investment	7,217	162.8	77.5
Allowance for startup and modifications	679	15.3	7.3
Interest during construction	866	19.5	9.3
Subtotal capital investment	8,762	197.6	94.1
Land	77	1.7	0.8
Working capital	472	10.7	5.1
Total capital investment	9,311	210.0	100.0

[a] Basis
Existing 200-MW plant (15-yr remaining life) 86 klb/hr (60% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities.
Land required for disposal, 22 acres at 30 ft deep.
Clarified sludge (35% solids) transported by pipeline to disposal/treatment area.
Fixation additives (% of dry solids): Portland cement - 7%, sodium silicate - 4%.

TABLE A-202. CHEMFIX PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 200-MW plant, 15-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Sodium silicate (38% soln)	3,115 tons	98.00/ton	305,300	6.3
Cement	11,806 tons	52.00/ton	613,900	12.6
Subtotal raw materials cost			919,200	18.9
Conversion costs				
Operating labor and supervision				
Plant	26,280 man-hr	12.50/man-hr	328,500	6.8
Solids disposal equipment	43,800 man-hr	17.00/man-hr	744,600	15.3
Maintenance--plant labor and material, 4% of direct investment			160,400	3.3
Landfill operation				
Land preparation			2,500	0.1
Trucks (fuel and maintenance)				
Earthmoving equipment (fuel and maintenance)	301,000 tons	0.30/ton	90,300	1.9
Electricity	2,175 kkWh	0.031/kWh	67,400	1.4
Analyses	1,000 hr	17.00/man-hr	17,000	0.3
Subtotal conversion costs			1,410,700	29.1
Subtotal direct costs			2,329,900	48.0
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 10.8% of total capital investment less land and working capital			946,300	19.5
Average cost of capital and taxes at 8.6% of total capital investment			800,700	16.5
Overhead				
Plant, 50% of conversion costs less utilities			671,700	13.8
Administrative, 10% of operating labor			107,300	2.2
Subtotal indirect costs			2,526,000	52.0
Total annual revenue requirements			4,855,900	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	27.01	16.13	3.47

a. Basis

Remaining plant life, 15 yr.
Coal burned, 180,952 lb/hr, 9,500 Btu/kWh
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $9,311,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-203. CHEMFIX PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 500-MW plant, 25-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,904	46.5	21.6
Piping and insulation	227	3.6	1.7
Transport lines	697	11.2	5.2
Foundation and structural	210	3.4	1.6
Excavation, site preparation, roads and railroads	162	2.6	1.2
Electrical	855	13.7	6.4
Instrumentation	107	1.7	0.8
Buildings	550	8.8	4.1
Subtotal	5,712	91.5	42.6
Services and miscellaneous	86	1.4	0.7
Subtotal excluding trucks and equipment	5,798	92.9	43.3
Trucks and earthmoving equipment	441	7.1	3.3
Subtotal direct investment	6,239	100.0	46.6
Engineering design and supervision	472	7.6	3.5
Architect and engineering contractor	118	1.9	0.9
Construction expense	1,075	17.2	8.0
Contractor fees	386	6.2	2.9
Subtotal	8,290	132.9	61.9
Contingency	1,658	26.5	12.4
Subtotal fixed investment	9,948	159.4	74.3
Allowance for startup and modifications	951	15.2	7.1
Interest during construction	1,194	19.2	8.9
Subtotal capital investment	12,093	193.8	90.3
Land	515	8.3	3.8
Working capital	792	12.7	5.9
Total capital investment	13,400	214.8	100.0

[a] Basis

Existing 500-MW plant (25-yr remaining life); 207 klb/hr (60% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979.

Coal analysis (by wt): 3.5% S (dry basis), 16% ash.

Flyash removed with SO_2.

SO_2 and flyash removed to meet NSPS.

Limestone process with 1.5 stoichiometry based on SO_2 removed.

Disposal in landfill 1 mi from scrubber facilities.

Land required for disposal, 147 acres at 30 ft deep.

Clarified sludge (35% solids) transported by pipeline to disposal/treatment area.

Fixation additives (% of dry solids): Portland cement - 7%, sodium silicate - 4%.

TABLE A-204. CHEMFIX PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 500-MW plant, 25-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Sodium silicate (38% soln)	7,525 tons	98.00/ton	737,500	10.3
Cement	28,574 tons	52.00/ton	1,485,800	20.8
Subtotal raw materials cost			2,223,300	31.1
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	6.1
Solids disposal equipment	43,800 man-hr	17.00/man-hr	744,600	10.4
Maintenance--plant labor and material, 4% of direct investment			231,900	3.3
Landfill operation				
Land preparation			10,000	0.1
Trucks (fuel and maintenance)				
Earthmoving equipment (fuel and maintenance)	724,500 tons	0.30/ton	217,400	3.0
Electricity	3,603 kkWh	0.029/kWh	104,500	1.5
Analyses	1,000 hr	17.00/man-hr	17,000	0.2
Subtotal conversion costs			1,763,400	24.6
Subtotal direct costs			3,986,700	55.7
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 8.8% of total capital investment less land and working capital			1,064,200	14.9
Average cost of capital and taxes at 8.6% of total capital investment			1,152,400	16.1
Overhead				
Plant, 50% of conversion costs less utilities			829,500	11.6
Administrative, 10% of operating labor			118,300	1.7
Subtotal indirect costs			3,165,000	44.3
Total annual revenue requirements			7,151,700	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	16.55	9.87	2.04	

[a] Basis
Remaining plant life, 25 yr.
Coal burned, 438,095 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $13,400,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-205. CHEMFIX PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 500-MW plant, 20-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,904	46.5	22.0
Piping and insulation	227	3.6	1.7
Transport lines	697	11.2	5.3
Foundation and structural	210	3.4	1.6
Excavation, site preparation, roads and railroads	162	2.6	1.2
Electrical	855	13.7	6.5
Instrumentation	107	1.7	0.8
Buildings	550	8.8	4.2
Subtotal	5,712	91.5	43.3
Services and miscellaneous	86	1.4	0.6
Subtotal excluding trucks and equipment	5,798	92.9	43.9
Trucks and earthmoving equipment	441	7.1	3.4
Subtotal direct investment	6,239	100.0	47.3
Engineering design and supervision	472	7.6	3.6
Architect and engineering contractor	118	1.9	0.9
Construction expense	1,075	17.2	8.1
Contractor fees	386	6.2	2.9
Subtotal	8,290	132.9	62.8
Contingency	1,658	26.5	12.5
Subtotal fixed investment	9,948	159.4	75.3
Allowance for startup and modifications	951	15.2	7.2
Interest during construction	1,194	19.2	9.1
Subtotal capital investment	12,093	193.8	91.6
Land	319	5.1	2.4
Working capital	792	12.7	6.0
Total capital investment	13,204	211.6	100.0

[a] Basis

Existing 500-MW plant (20-yr remaining life); 207 klb/hr (60% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities.
Land required for disposal, 91 acres at 30 ft deep.
Clarified sludge (35% solids) transported by pipeline to disposal/treatment area.
Fixation additives (% of dry solids): Portland cement - 7%, sodium silicate - 4%.

TABLE A-206. CHEMFIX PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 500-MW plant, 20-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Sodium silicate (38% soln)	7,525 tons	98.00/ton	737,500	10.3
Cement	28,574 tons	52.00/ton	1,485,800	20.6
Subtotal raw materials cost			2,223,300	30.9
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	6.1
Solids disposal equipment	43,800 man-hr	17.00/man-hr	744,600	10.4
Maintenance--plant labor and material, 4% of direct investment			231,900	3.2
Landfill operation				
Land preparation			7,700	0.1
Trucks (fuel and maintenance)				
Earthmoving equipment (fuel and maintenance)	724,500 tons	0.30/ton	217,400	3.0
Electricity	3,603 kkWh	0.029/kWh	104,500	1.5
Analyses	1,000 hr	17.00/man-hr	17,000	0.2
Subtotal conversion costs			1,761,100	24.5
Subtotal direct costs			3,984,400	55.4
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 9.3% of total capital investment less land and working capital			1,124,600	15.6
Average cost of capital and taxes at 8.6% of total capital investment			1,135,500	15.8
Overhead				
Plant, 50% of conversion costs less utilities			828,300	11.5
Administrative, 10% of operating labor			118,300	1.7
Subtotal indirect costs			3,206,700	44.6
Total annual revenue requirements			7,191,100	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	16.64	9.92	2.05	

a. Basis

Remaining plant life, 20 yr.
Coal burned, 438,095 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $13,204,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-207. CHEMFIX PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 500-MW plant, 15-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,904	46.5	22.4
Piping and insulation	227	3.6	1.7
Transport lines	697	11.2	5.3
Foundation and structural	210	3.4	1.6
Excavation, site preparation, roads and railroads	162	2.6	1.2
Electrical	855	13.7	6.5
Instrumentation	107	1.7	0.8
Buildings	550	8.8	4.2
Subtotal	5,712	91.5	43.7
Services and miscellaneous	86	1.4	0.7
Subtotal excluding trucks and equipment	5,798	92.9	44.4
Trucks and earthmoving equipment	441	7.1	3.4
Subtotal direct investment	6,239	100.0	47.8
Engineering design and supervision	472	7.6	3.6
Architect and engineering contractor	118	1.9	0.9
Construction expense	1,075	17.2	8.2
Contractor fees	386	6.2	2.9
Subtotal	8,290	132.9	63.4
Contingency	1,658	26.5	12.7
Subtotal fixed investment	9,948	159.4	76.1
Allowance for startup and modifications	951	15.2	7.3
Interest during construction	1,194	19.2	9.1
Subtotal capital investment	12,093	193.8	92.5
Land	182	2.9	1.4
Working capital	792	12.7	6.1
Total capital investment	13,067	209.4	100.0

a. Basis

Existing 500-MW plant (15-yr remaining life); 207 klb/hr (60% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979.

Coal analysis (by wt): 3.5% S (dry basis), 16% ash.

Flyash removed with SO_2.

SO_2 and flyash removed to meet NSPS.

Limestone process with 1.5 stoichiometry based on SO_2 removed.

Disposal in landfill 1 mi from scrubber facilities.

Land required for disposal, 52 acres at 30 ft deep.

Clarified sludge (35% solids) transported by pipeline to disposal/treatment area.

Fixation additives (% of dry solids): Portland cement - 7%, sodium silicate - 4%.

TABLE A-208. CHEMFIX PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 500-MW plant, 15-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Sodium silicate (38% soln)	7,525 tons	98.00/ton	737,500	10.0
Cement	28,574 tons	52.00/ton	1,485,800	20.2
Subtotal raw materials cost			2,223,300	30.2
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	5.9
Solids disposal equipment	43,800 man-hr	17.00/man-hr	744,600	10.1
Maintenance--plant labor and material, 4% of direct investment			231,900	3.2
Landfill operation				
Land preparation			5,900	0.1
Trucks (fuel and maintenance)				
Earthmoving equipment (fuel and maintenance)	724,500 tons	0.30/ton	217,400	3.0
Electricity	3,603 kkWh	0.029/kWh	104,500	1.4
Analyses	1,000 hr	17.00/man-hr	17,000	0.2
Subtotal conversion costs			1,759,300	23.9
Subtotal direct costs			3,982,600	54.1
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 10.8% of total capital investment less land and working capital			1,306,000	17.8
Average cost of capital and taxes at 8.6% of total capital investment			1,124,600	15.3
Overhead				
Plant, 50% of conversion costs less utilities			827,400	11.2
Administrative, 10% of operating labor			118,300	1.6
Subtotal indirect costs			3,376,300	45.9
Total annual revenue requirements			7,358,900	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	17.03	10.16	2.10	

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a. Basis

Remaining plant life, 15 yr.
Coal burned, 438,095 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $13,077,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-209. CHEMFIX PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: 1500-MW plant)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	5,499	50.7	22.8
Piping and insulation	367	3.4	1.5
Transport lines	1,027	9.5	4.3
Foundation and structural	394	3.6	1.6
Excavation, site preparation, roads and railroads	239	2.2	1.0
Electrical	1,274	11.7	5.3
Instrumentation	119	1.1	0.5
Buildings	1,004	9.2	4.2
Subtotal	9,923	91.4	41.2
Services and miscellaneous	149	1.3	0.6
Subtotal excluding trucks and equipment	10,072	92.7	41.8
Trucks and earthmoving equipment	789	7.3	3.3
Subtotal direct investment	10,861	100.0	45.1
Engineering design and supervision	564	5.2	2.3
Architect and engineering contractor	141	1.3	0.6
Construction expense	1,700	15.7	7.1
Contractor fees	588	5.4	2.4
Subtotal	13,854	127.6	57.5
Contingency	2,771	25.5	11.5
Subtotal fixed investment	16,625	153.1	69.0
Allowance for startup and modifications	1,584	14.6	6.6
Interest during construction	1,995	18.3	8.2
Subtotal capital investment	20,204	186.0	83.8
Land	2,083	19.2	8.6
Working capital	1,817	16.7	7.6
Total capital investment	24,104	221.9	100.0

[a] Basis

New 1500-MW plant (30-yr life); 609 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities.
Land required for disposal, 595 acres at 30 ft deep.
Clarified sludge (35% solids) transported by pipeline to disposal/treatment area.
Fixation additives (% of dry solids): Portland cement - 7%, sodium silicate - 4%.

TABLE A-210. CHEMFIX PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 1500-MW plant)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Sodium silicate (38% soln)	22,050 tons	98.00/ton	2,160,900	15.0
Cement	83,860 tons	52.00/ton	4,360,700	30.4
Subtotal raw materials cost			6,521,600	45.4
Conversion costs				
Operating labor and supervision				
Plant	43,800 man-hr	12.50/man-hr	547,500	3.8
Solids disposal equipment	52,560 man-hr	17.00/man-hr	893,500	6.2
Maintenance--plant labor and material, 4% of direct investment			402,900	2.8
Landfill operation				
Land preparation			34,000	0.2
Trucks (fuel and maintenance)				
Earthmoving equipment (fuel and maintenance)	2,131,300 tons	0.30/ton	639,400	4.5
Electricity	8,419 kkWh	0.027/kWh	227,300	1.6
Analyses	1,500 hr	17.00/man-hr	25,500	0.2
Subtotal conversion costs			2,770,100	19.3
Subtotal direct costs			9,291,700	64.7
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			1,582,000	11.0
Average cost of capital and taxes at 8.6% of total capital investment			2,072,900	14.4
Overhead				
Plant, 50% of conversion costs less utilities			1,271,400	8.9
Administrative, 10% of operating labor			144,100	1.0
Subtotal indirect costs			5,070,400	35.3
Total annual revenue requirements			14,362,100	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	11.31	6.74	1.37	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 1,285,714 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $24,104,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-211. CHEMFIX PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 1500-MW plant, 25-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	5,660	51.2	23.6
Piping and insulation	377	3.4	1.6
Transport lines	1,027	9.3	4.3
Foundation and structural	397	3.6	1.7
Excavation, site preparation, roads and railroads	240	2.2	1.0
Electrical	1,281	11.6	5.4
Instrumentation	119	1.1	0.5
Buildings	1,004	9.1	4.2
Subtotal	10,105	91.5	42.3
Services and miscellaneous	152	1.4	0.6
Subtotal excluding trucks and equipment	10,257	92.9	42.9
Trucks and earthmoving equipment	789	7.1	3.3
Subtotal direct investment	11,046	100.0	46.2
Engineering design and supervision	564	5.1	2.4
Architect and engineering contractor	141	1.3	0.6
Construction expense	1,726	15.6	7.1
Contractor fees	596	5.4	2.5
Subtotal	14,073	127.4	58.8
Contingency	2,815	25.5	11.8
Subtotal fixed investment	16,888	152.9	70.6
Allowance for startup and modifications	1,610	14.6	6.7
Interest during construction	2,027	18.3	8.5
Subtotal capital investment	20,525	185.8	85.8
Land	1,547	14.0	6.5
Working capital	1,850	16.8	7.7
Total capital investment	23,922	216.6	100.0

a. Basis
Existing 1500-MW plant (25-yr remaining life); 623 klb/hr (60% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis, 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities.
Land required for disposal, 442 acres at 30 ft deep.
Clarified sludge (35% solids) transported by pipeline to disposal/treatment area.
Fixation additives (% of dry solids): Portland cement - 7%, sodium silicate - 4%.

TABLE A-212. CHEMFIX PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 1500-MW plant, 25-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Sodium silicate (38% soln)	22,579 tons	98.00/ton	2,212,700	15.0
Cement	85,719 tons	52.00/ton	4,457,400	30.2
Subtotal raw materials cost			6,670,100	45.2
Conversion costs				
Operating labor and supervision				
Plant	43,800 man-hr	12.50/man-hr	547,500	3.7
Solids disposal equipment	52,560 man-hr	17.00/man-hr	893,500	6.0
Maintenance--plant labor and material, 4% of direct investment			410,300	2.8
Landfill operation				
Land preparation			29,900	0.2
Trucks (fuel and maintenance)				
Earthmoving equipment (fuel and maintenance)	2,180,500 tons	0.30/ton	654,200	4.4
Electricity	8,497 kkWh	0.027/kWh	229,400	1.6
Analyses	1,500 hr	17.00/man-hr	25,500	0.2
Subtotal conversion costs			2,790,300	18.9
Subtotal direct costs			9,460,400	64.1
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 8.8% of total capital investment less land and working capital			1,806,200	12.3
Average cost of capital and taxes at 8.6% of total capital investment			2,057,300	13.9
Overhead				
Plant, 50% of conversion costs less utilities			1,280,500	8.7
Administrative, 10% of operating labor			144,100	1.0
Subtotal indirect costs			5,288,100	35.9
Total annual revenue requirements			14,748,500	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	11.36	6.76	1.40	

a. Basis
Remaining plant life, 25 yr.
Coal burned, 1,314,286 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $23,922,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-213. CHEMFIX PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 1500-MW plant, 20-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	5,660	51.2	24.3
Piping and insulation	377	3.4	1.6
Transport lines	1,027	9.3	4.4
Foundation and structural	397	3.6	1.7
Excavation, site preparation, roads and railroads	240	2.2	1.0
Electrical	1,281	11.6	5.5
Instrumentation	119	1.1	0.5
Buildings	1,004	9.1	4.3
Subtotal	10,105	91.5	43.3
Services and miscellaneous	152	1.4	0.6
Subtotal excluding trucks and equipment	10,257	92.9	43.9
Trucks and earthmoving equipment	789	7.1	3.4
Subtotal direct investment	11,046	100.0	47.3
Engineering design and supervision	564	5.1	2.4
Architect and engineering contractor	141	1.3	0.6
Construction expense	1,726	15.6	7.4
Contractor fees	596	5.4	2.6
Subtotal	14,073	127.4	60.3
Contingency	2,815	25.5	12.1
Subtotal fixed investment	16,888	152.9	72.4
Allowance for startup and modifications	1,610	14.6	6.9
Interest during construction	2,027	18.3	8.7
Subtotal capital investment	20,525	185.8	88.0
Land	963	8.7	4.1
Working capital	1,849	16.8	7.9
Total capital investment	23,337	211.3	100.0

[a] Basis

Existing 1500-MW plant (20-yr remaining life); 623 klb/hr (60% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979.

Coal analysis (by wt): 3.5% S (dry basis), 16% ash.

Flyash removed with SO_2.

SO_2 and flyash removed to meet NSPS.

Limestone process with 1.5 stoichiometry based on SO_2 removed.

Disposal in landfill 1 mi from scrubber facilities.

Land required for disposal, 275 acres at 30 ft deep.

Clarified sludge (35% solids) transported by pipeline to disposal/treatment area.

Fixation additives (% of dry solids): Portland cement - 7%, sodium silicate - 4%.

TABLE A-214. CHEMFIX PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 1500-MW plant, 20-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Sodium silicate (38% soln)	22,579 tons	98.00/ton	2,212,700	15.0
Cement	85,719 tons	52.00/ton	4,457,400	30.1
Subtotal raw materials cost			6,670,100	45.1
Conversion costs				
Operating labor and supervision				
Plant	43,800 man-hr	12.50/man-hr	547,500	3.7
Solids disposal equipment	52,560 man-hr	17.00/man-hr	893,500	6.0
Maintenance--plant labor and material, 4% of direct investment			410,300	2.8
Landfill operation				
Land preparation			23,300	0.2
Trucks (fuel and maintenance)				
Earthmoving equipment (fuel and maintenance)	2,180,500 tons	0.30/ton	654,200	4.4
Electricity	8,497 kkWh	0.027/kWh	229,400	1.5
Analyses	1,500 hr	17.00/man-hr	25,500	0.2
Subtotal conversion costs			2,783,700	18.8
Subtotal direct costs			9,453,800	63.9
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 9.3% of total capital investment less land and working capital			1,908,800	12.9
Average cost of capital and taxes at 8.6% of total capital investment			2,007,000	13.6
Overhead				
Plant, 50% of conversion costs less utilities			1,277,200	8.6
Administrative, 10% of operating labor			144,100	1.0
Subtotal indirect costs			5,337,100	36.1
Total annual revenue requirements			14,790,900	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	11.39	6.78	1.41	

[a] Basis
Remaining plant life, 20 yr.
Coal burned, 1,314,286 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $23,337,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-215. CHEMFIX PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: existing 1500-MW plant, 15-yr remaining life)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	5,660	51.2	24.7
Piping and insulation	377	3.4	1.6
Transport lines	1,027	9.3	4.5
Foundation and structural	297	3.6	1.7
Excavation, site preparation, roads and railroads	240	2.2	1.1
Electrical	1,281	11.6	5.6
Instrumentation	119	1.1	0.5
Buildings	1,004	9.1	4.4
Subtotal	10,105	91.5	44.1
Services and miscellaneous	152	1.4	0.7
Subtotal excluding trucks and equipment	10,257	92.9	44.8
Trucks and earthmoving equipment	789	7.1	3.4
Subtotal direct investment	11,046	100.0	48.2
Engineering design and supervision	564	5.1	2.5
Architect and engineering contractor	141	1.3	0.6
Construction expense	1,726	15.6	7.5
Contractor fees	596	5.4	2.6
Subtotal	14,073	127.4	61.4
Contingency	2,815	25.5	12.3
Subtotal fixed investment	16,888	152.9	73.7
Allowance for startup and modifications	1,610	14.6	7.0
Interest during construction	2,027	18.3	8.9
Subtotal capital investment	20,525	185.8	89.6
Land	543	4.9	2.4
Working capital	1,847	16.7	8.0
Total capital investment	22,915	207.4	100.0

[a] Basis

Existing 1500-MW plant (15-yr remaining life); 623 klb/hr (60% solids) sludge; Midwest plant location; average basis for cost scaling, mid-1979.

Coal analysis (by wt): 3.5% S (dry basis), 16% ash.

Flyash removed with SO_2.

SO_2 and flyash removed to meet NSPS.

Limestone process with 1.5 stoichiometry based on SO_2 removed.

Disposal in landfill 1 mi from scrubber facilities.

Land required for disposal, 155 acres at 30 ft deep.

Clarified sludge (35% solids) transported by pipeline to disposal/treatment area.

Fixation additives (% of dry solids): Portland cement - 7%, sodium silicate - 4%.

TABLE A-216. CHEMFIX PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: existing 1500-MW plant, 15-yr remaining life)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Sodium silicate (38% soln)	22,579 tons	98.00/ton	2,212,700	14.7
Cement	85,719 tons	52.00/ton	4,457,400	29.6
Subtotal raw materials cost			6,670,100	44.3
Conversion costs				
Operating labor and supervision				
Plant	43,800 man-hr	12.50/man-hr	547,500	3.6
Solids disposal equipment	52,560 man-hr	17.00/man-hr	893,500	6.0
Maintenance--plant labor and material, 4% of direct investment			410,300	2.7
Landfill operation				
Land preparation			17,500	0.1
Trucks (fuel and maintenance)				
Earthmoving equipment (fuel and maintenance)	2,180,500 tons	0.30/ton	654,200	4.4
Electricity	8,497 kkWh	0.027/kWh	229,400	1.5
Analyses	1,500 hr	17.00/man-hr	25,500	0.2
Subtotal conversion costs			2,777,900	18.5
Subtotal direct costs			9,448,000	62.8
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 10.8% of total capital investment less land and working capital			2,216,700	14.7
Average cost of capital and taxes at 8.6% of total capital investment			1,970,700	13.0
Overhead				
Plant, 50% of conversion costs less utilities			1,274,300	8.5
Administrative, 10% of operating labor			144,100	1.0
Subtotal indirect costs			5,605,800	37.2
Total annual revenue requirements			15,053,800	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	11.59	6.90	1.43	

a. Basis

Remaining plant life, 15 yr.
Coal burned, 1,314,286 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $22,915,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-217. CHEMFIX PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: 12% ash in coal)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,508	46.1	21.2
Piping and insulation	191	3.5	1.6
Transport lines	487	9.0	4.1
Foundation and structural	159	2.9	1.3
Excavation, site preparation, roads and railroads	154	2.8	1.3
Electrical	764	14.1	6.4
Instrumentation	107	2.0	0.9
Buildings	550	10.1	4.6
Subtotal	4,920	90.5	41.4
Services and miscellaneous	74	1.4	0.7
Subtotal excluding trucks and equipment	4,994	91.9	42.1
Trucks and earthmoving equipment	441	8.1	3.7
Subtotal direct investment	5,435	100.0	45.8
Engineering design and supervision	438	8.1	3.7
Architect and engineering contractor	110	2.0	0.9
Construction expense	950	17.5	8.0
Contractor fees	348	6.4	2.9
Subtotal	7,281	134.0	61.3
Contingency	1,456	26.8	12.3
Subtotal fixed investment	8,737	160.8	73.6
Allowance for startup and modifications	830	15.3	7.0
Interest during construction	1,048	19.2	8.8
Subtotal capital investment	10,615	195.3	89.4
Land	571	10.5	4.8
Working capital	693	12.8	5.8
Total capital investment	11,879	218.6	100.0

a. Basis
New 500-MW plant (30-yr life); 167 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 12% ash, 11,100 Btu/lb HV.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities.
Land required for disposal, 163 acres at 30 ft deep.
Clarified sludge (35% solids) transported by pipeline to disposal/treatment area.
Fixation additives (% of dry solids): Portland cement - 7%, sodium silicate - 4%.

TABLE A-218. CHEMFIX PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 12% ash in coal)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Sodium silicate (38% soln)	6,076 tons	98.00/ton	595,400	9.5
Cement	23,093 tons	52.00/ton	1,200,800	19.3
Subtotal raw materials cost			1,796,200	28.8
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	7.0
Solids disposal equipment	43,800 man-hr	17.00/man-hr	744,600	12.0
Maintenance--plant labor and material, 4% of direct investment			199,800	3.2
Landfill operation				
Land preparation			9,000	0.1
Trucks (fuel and maintenance)				
Earthmoving equipment (fuel and maintenance)	584,500 tons	0.30/ton	175,400	2.8
Electricity	2,948 kkWh	0.029/kWh	85,500	1.4
Analyses	1,000 hr	17.00/man-hr	17,000	0.3
Subtotal conversion costs			1,669,300	26.8
Subtotal direct costs			3,465,500	55.6
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			831,200	13.4
Average cost of capital and taxes at 8.6% of total capital investment			1,021,600	16.4
Overhead				
Plant, 50% of conversion costs less utilities			791,900	12.7
Administrative, 10% of operating labor			118,300	1.9
Subtotal indirect costs			2,763,000	44.4
Total annual revenue requirements			6,228,500	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	17.86	10.66	1.78

a. Basis

Remaining plant life, 30 yr.
Coal burned, 405,405 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $11,879,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-219. CHEMFIX PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: 20% ash in coal)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	3,037	46.9	21.4
Piping and insulation	250	3.9	1.8
Transport lines	697	10.8	4.9
Foundation and structural	225	3.5	1.6
Excavation, site preparation, roads and railroads	166	2.6	1.2
Electrical	878	13.6	6.2
Instrumentation	107	1.6	0.7
Buildings	550	8.5	3.9
Subtotal	5,910	91.4	41.7
Services and miscellaneous	89	1.4	0.6
Subtotal excluding trucks and equipment	5,999	92.8	42.3
Trucks and earthmoving equipment	468	7.2	3.3
Subtotal direct investment	6,467	100.0	45.6
Engineering design and supervision	472	7.3	3.3
Architect and engineering contractor	118	1.8	0.8
Construction expense	1,106	17.2	7.8
Contractor fees	397	6.1	2.8
Subtotal	8,560	132.4	60.3
Contingency	1,712	26.4	12.1
Subtotal fixed investment	10,272	158.8	72.4
Allowance for startup and modifications	980	15.2	6.9
Interest during construction	1,233	19.1	8.7
Subtotal capital investment	12,485	193.1	88.0
Land	830	12.8	5.8
Working capital	877	13.6	6.2
Total capital investment	14,192	219.5	100.0

[a] Basis

New 500-MW plant (30-yr life); 243 klb/hr (60% solids) sludge.
Midwest location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 20% ash, 9,900 Btu/lb HV.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removal.
Disposal in landfill 1 mi from scrubber facilities.
Land required for disposal, 237 acres at 30 ft deep.
Clarified sludge (35% solids) transported by pipeline to disposal/treatment area.
Fixation additives (% of dry solids): Portland cement - 7%, sodium silicate - 4%.

TABLE A-220. CHEMFIX PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 20% ash in coal)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Sodium silicate (38% soln)	8,796 tons	98.00/ton	862,000	11.3
Cement	33,415 tons	52.00/ton	1,737,600	22.9
Subtotal raw materials cost			2,599,600	34.2
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	5.7
Solids disposal equipment	43,800 man-hr	17.00/man-hr	744,600	9.8
Maintenance--plant labor and material, 4% of direct investment			240,000	3.2
Landfill operation				
Land preparation			13,000	0.2
Trucks (fuel and maintenance)				
Earthmoving equipment (fuel and maintenance)	850,500 tons	0.30/ton	255,200	3.4
Electricity	4,204 kkWh	0.029/kWh	121,900	1.6
Analyses	1,000 hr	17.00/man-hr	17,000	0.2
Subtotal conversion costs			1,829,700	24.1
Subtotal direct costs			4,429,300	58.3
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			977,600	12.9
Average cost of capital and taxes at 8.6% of total capital investment			1,220,500	16.0
Overhead				
Plant, 50% of conversion costs less utilities			853,900	11.2
Administrative, 10% of operating labor			118,300	1.6
Subtotal indirect costs			3,170,300	41.7
Total annual revenue requirements			7,599,600	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	15.00	8.93	2.17

a. Basis
Remaining plant life, 30 yr.
Coal burned, 454,545 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $14,192,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-221. CHEMFIX PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: 2% S in coal)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,282	44.8	20.5
Piping and insulation	190	3.7	1.7
Transport lines	487	9.6	4.4
Foundation and structural	148	2.9	1.3
Excavation, site preparation, roads and railroads	150	2.9	1.4
Electrical	707	13.9	6.4
Instrumentation	89	1.7	0.8
Buildings	550	10.8	4.9
Subtotal	4,603	90.3	41.4
Services and miscellaneous	69	1.4	0.6
Subtotal excluding trucks and equipment	4,672	91.7	42.0
Trucks and earthmoving equipment	423	8.3	3.8
Subtotal direct investment	5,095	100.0	45.8
Engineering design and supervision	415	8.1	3.7
Architect and engineering contractor	104	2.0	0.9
Construction expense	899	17.7	8.1
Contractor fees	331	6.5	3.0
Subtotal	6,844	134.3	61.5
Contingency	1,369	26.9	12.3
Subtotal fixed investment	8,213	161.2	73.8
Allowance for startup and modifications	779	15.3	7.0
Interest during construction	986	19.3	8.9
Subtotal capital investment	9,978	195.8	89.7
Land	483	9.5	4.3
Working capital	662	13.0	6.0
Total capital investment	11,123	218.3	100.0

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a. Basis

New 500-MW plant (30-yr life); 141 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 2.0% S (dry basis), 16% ash, 10,700 Btu/lb HV.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities.
Land required for disposal, 138 acres at 30 ft deep.
Clarified sludge (35% solids) transported by pipeline to disposal/treatment area.
Fixation additives (% of dry solids): Portland cement - 7%, sodium silicate - 4%.

TABLE A-222. CHEMFIX PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 2% S in coal)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Sodium silicate (38% soln)	5,660 tons	98.00/ton	554,700	9.3
Cement	21,540 tons	52.00/ton	1,120,100	18.9
Subtotal raw materials cost			1,674,800	28.2
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	7.4
Solids disposal equipment	43,800 man-hr	17.00/man-hr	744,600	12.5
Maintenance--plant labor and material, 4% of direct investment			186,900	3.2
Landfill operation				
Land preparation			8,000	0.1
Trucks (fuel and maintenance)				
Earthmoving equipment (fuel and maintenance)	493,500 tons	0.30/ton	148,000	2.5
Electricity	3,104 kkWh	0.029/kWh	90,000	1.5
Analyses	1,000 hr	17.00/man-hr	17,000	0.3
Subtotal conversion costs			1,632,500	27.5
Subtotal direct costs			3,307,300	55.7
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			781,300	13.2
Average cost of capital and taxes at 8.6% of total capital investment			956,600	16.1
Overhead				
Plant, 50% of conversion costs less utilities			771,300	13.0
Administrative, 10% of operating labor			118,300	2.0
Subtotal indirect costs			2,627,500	44.3
Total annual revenue requirements			5,934,800	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	20.19	12.02	1.70

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a. Basis

Remaining plant life, 30 yr.
Coal burned, 420,561 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $11,123,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-223. CHEMFIX PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: 5% S in coal)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	3,198	47.6	21.5
Piping and insulation	244	3.6	1.6
Transport lines	697	10.4	4.7
Foundation and structural	254	3.8	1.7
Excavation, site preparation, roads and railroads	169	2.5	1.1
Electrical	929	13.8	6.4
Instrumentation	118	1.8	0.8
Buildings	550	8.2	3.7
Subtotal	6,159	91.7	41.5
Services and miscellaneous	92	1.3	0.6
Subtotal excluding trucks and equipment	6,251	93.0	42.1
Trucks and earthmoving equipment	468	7.0	3.1
Subtotal direct investment	6,719	100.0	45.2
Engineering design and supervision	495	7.4	3.3
Architect and engineering contractor	124	1.8	0.8
Construction expense	1,144	17.0	7.7
Contractor fees	408	6.1	2.8
Subtotal	8,890	132.3	59.8
Contingency	1,778	26.5	12.0
Subtotal fixed investment	10,668	158.8	71.8
Allowance for startup and modifications	1,020	15.2	6.9
Interest during construction	1,280	19.0	8.6
Subtotal capital investment	12,968	193.0	87.3
Land	903	13.5	6.1
Working capital	983	14.6	6.6
Total capital investment	14,854	221.1	100.0

[a] Basis
New 500-MW plant (30-yr life); 264 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 5% S (dry basis), 16% ash, 10,400 Btu/lb HV.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities.
Land required for disposal, 258 acres at 30 ft deep.
Clarified sludge (35% solids) transported by pipeline to disposal/treatment area.
Fixation additives (% of dry solids): Portland cement - 7%, sodium silicate - 4%.

TABLE A-224. CHEMFIX PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 5% S in coal)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Sodium silicate (38% soln)	10,520 tons	98.00/ton	1,031,000	12.5
Cement	40,040 tons	52.00/ton	2,082,100	25.2
Subtotal raw materials cost			3,113,100	37.7
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	5.3
Solids disposal equipment	43,800 man-hr	17.00/man-hr	744,600	9.0
Maintenance--plant labor and material, 4% of direct investment			250,000	3.0
Landfill operation				
Land preparation			15,000	0.2
Trucks (fuel and maintenance)				
Earthmoving equipment (fuel and maintenance)	924,000 tons	0.30/ton	277,200	3.4
Electricity	4,355 kkWh	0.029/kWh	126,300	1.5
Analyses	1,000 hr	17.00/man-hr	17,000	0.2
Subtotal conversion costs			1,868,100	22.6
Subtotal direct costs			4,981,200	60.3
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			1,015,400	12.3
Average cost of capital and taxes at 8.6% of total capital investment			1,277,400	15.5
Overhead				
Plant, 50% of conversion costs less utilities			870,900	10.5
Administrative, 10% of operating labor			118,300	1.4
Subtotal indirect costs			3,282,000	39.7
Total annual revenue requirements			8,263,200	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	15.01	8.94	2.36	

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a. Basis

Remaining plant life, 30 yr.
Coal burned, 432,692 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $14,854,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-225. CHEMFIX PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: 200-MW plant, no flyash)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	1,364	38.0	17.5
Piping and insulation	155	4.3	2.0
Transport lines	326	9.1	4.2
Foundation and structural	86	2.4	1.1
Excavation, site preparation, roads and railroads	130	3.6	1.7
Electrical	515	14.3	6.6
Instrumentation	82	2.3	1.1
Buildings	550	15.3	7.1
Subtotal	3,208	89.3	41.3
Services and miscellaneous	48	1.3	0.6
Subtotal excluding trucks and equipment	3,256	90.6	41.9
Trucks and earthmoving equipment	337	9.4	4.3
Subtotal direct investment	3,593	100.0	46.2
Engineering design and supervision	369	10.3	4.7
Architect and engineering contractor	92	2.6	1.2
Construction expense	666	18.4	8.6
Contractor fees	254	7.1	3.3
Subtotal	4,974	138.4	64.0
Contingency	995	27.7	12.8
Subtotal fixed investment	5,969	166.1	76.8
Allowance for startup and modifications	563	15.7	7.3
Interest during construction	716	19.9	9.2
Subtotal capital investment	7,248	201.7	93.3
Land	151	4.2	1.9
Working capital	368	10.3	4.7
Total capital investment	7,767	216.2	100.0

a. Basis
New 200-MW plant (30-yr life); 44 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed independently of SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities.
Land required for disposal, 43 acres at 30 ft deep.
Clarified sludge (35% solids) transported by pipeline to disposal/treatment area.
Fixation additives (% of dry solids): Portland cement - 7%, sodium silicate - 4%.

TABLE A-226. CHEMFIX PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 200-MW plant, separate system for disposal/removal of flyash)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Sodium silicate (38% soln)	1,596 tons	98.00/ton	156,400	4.1
Cement	6,062 tons	52.00/ton	315,200	8.4
Subtotal raw materials cost			471,600	12.5
Conversion costs				
Operating labor and supervision				
Plant	26,280 man-hr	12.50/man-hr	328,500	8.7
Solids disposal equipment	43,800 man-hr	17.00/man-hr	744,600	19.8
Maintenance--plant labor and material, 4% of direct investment			125,800	3.3
Landfill operation				
Land preparation			2,000	0.1
Trucks (fuel and maintenance)				
Earthmoving equipment (fuel and maintenance)	154,000 tons	0.30/ton	46,200	1.2
Electricity	1,794 kkWh	0.031/kWh	55,600	1.5
Analyses	1,000 hr	17.00/man-hr	17,000	0.5
Subtotal conversion costs			1,319,700	35.1
Subtotal direct costs			1,791,300	47.6
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			567,500	15.1
Average cost of capital and taxes at 8.6% of total capital investment			668,000	17.7
Overhead				
Plant, 50% of conversion costs less utilities			632,100	16.8
Administrative, 10% of operating labor			107,300	2.8
Subtotal indirect costs			1,974,900	52.4
Total annual revenue requirements			3,766,200	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	40.89	24.45	2.69	

a. Basis

Remaining plant life, 30 yr.
Coal burned, 175,238 lb/hr, 9,200 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $7,767,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-227. CHEMFIX PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: no flyash)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,083	43.9	20.2
Piping and insulation	188	4.0	1.8
Transport lines	487	10.3	4.7
Foundation and structural	105	2.2	0.2
Excavation, site preparation, roads and railroads	140	3.0	1.4
Electrical	600	12.6	5.8
Instrumentation	87	1.8	0.8
Buildings	550	11.6	5.3
Subtotal	4,240	89.4	41.2
Services and miscellaneous	64	1.3	0.6
Subtotal excluding trucks and equipment	4,304	90.7	41.8
Trucks and earthmoving equipment	441	9.3	4.3
Subtotal direct investment	4,745	100.0	46.1
Engineering design and supervision	392	8.3	3.8
Architect and engineering contractor	98	2.1	0.9
Construction expense	840	17.6	8.2
Contractor fees	313	6.6	3.0
Subtotal	6,388	134.6	62.0
Contingency	1,278	27.0	12.4
Subtotal fixed investment	7,666	161.6	74.4
Allowance for startup and modifications	723	15.2	7.0
Interest during construction	920	19.4	9.0
Subtotal capital investment	9,309	196.2	90.4
Land	547	11.5	5.3
Working capital	447	9.4	4.3
Total capital investment	10,303	217.1	100.0

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[a] Basis
New 500-MW plant (30-yr life); 107 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed independently of SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities.
Land required for disposal, 105 acres at 30 ft deep.
Clarified sludge (35% solids) transported by pipeline to disposal/treatment area.
Fixation additives (% of dry solids): Portland cement - 7%, sodium silicate - 4%.

TABLE A-228. CHEMFIX PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: no flyash)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Sodium silicate (38% soln)	3,899 tons	98.00/ton	382,100	7.4
Cement	14,826 tons	52.00/ton	771,000	14.8
Subtotal raw materials cost			1,153,100	22.2
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	8.4
Solids disposal equipment	43,800 man-hr	17.00/man-hr	744,600	14.4
Maintenance--plant labor and material, 4% of direct investment			167,000	3.2
Landfill operation				
Land preparation			6,000	0.1
Trucks (fuel and maintenance)				
Earthmoving equipment (fuel and maintenance)	374,500 tons	0.30/ton	112,400	2.2
Electricity	2,415 kkWh	0.029/kWh	70,000	1.4
Analyses	1,000 hr	17.00/man-hr	17,000	0.3
Subtotal conversion costs			1,555,000	30.0
Subtotal direct costs			2,708,100	52.2
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			728,900	14.1
Average cost of capital and taxes at 8.6% of total capital investment			886,100	17.1
Overhead				
Plant, 50% of conversion costs less utilities			742,500	14.3
Administrative, 10% of operating labor			118,300	2.3
Subtotal indirect costs			2,475,800	47.8
Total annual revenue requirements			5,183,900	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	23.17	13.84	1.48	

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a. Basis

Remaining plant life, 30 yr.
Coal burned, 482,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $10,124,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-229. CHEMFIX PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: 1500-MW plant, no flyash)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	3,873	45.8	21.4
Piping and insulation	264	3.1	1.5
Transport lines	854	10.1	4.7
Foundation and structural	297	3.5	1.6
Excavation, site preparation, roads and railroads	178	2.1	1.0
Electrical	961	11.4	5.3
Instrumentation	118	1.4	0.7
Buildings	1,004	11.9	5.5
Subtotal	7,549	89.3	41.6
Services and miscellaneous	113	1.4	0.6
Subtotal excluding trucks and	7,662	90.7	42.3
equipment	7,662	90.7	42.3
Trucks and earthmoving equipment	789	9.3	4.4
Subtotal direct investment	8,451	100.0	46.6
Engineering design and supervision	495	5.9	2.7
Architect and engineering contractor	124	1.5	0.7
Construction expense	1,355	15.9	7.5
Contractor fees	486	5.8	2.7
Subtotal	10,911	129.1	60.2
Contingency	2,182	25.8	12.0
Subtotal fixed investment	13,093	154.9	72.2
Allowance for startup and modifications	1,230	14.6	6.8
Interest during construction	1,571	18.6	8.7
Subtotal capital investment	15,894	188.1	87.7
Land	1,106	13.1	6.1
Working capital	1,133	13.4	6.3
Total capital investment	18,133	214.6	100.0

[a] Basis
New 1500-MW plant (30-yr life); 323 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed independently of SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities.
Land required for disposal, 316 acres at 30 ft deep.
Clarified sludge (35% solids) transported by pipeline to disposal/treatment area.
Fixation additives (% of dry solids): Portland cement - 7%, sodium silicate - 4%.

TABLE A-230. CHEMFIX PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 1500-MW plant)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Sodium silicate (38% soln)	11,711 tons	98.00/ton	1,147,700	11.9
Cement	44,464 tons	52.00/ton	2,312,100	24.0
Subtotal raw materials cost			3,459,800	35.9
Conversion costs				
Operating labor and supervision				
Plant	43,800 man-hr	12.50/man-hr	547,500	5.7
Solids disposal equipment	52,560 man-hr	17.00/man-hr	893,500	9.3
Maintenance--plant labor and material, 4% of direct investment			298,900	3.1
Landfill operation				
Land preparation			18,000	0.2
Trucks (fuel and maintenance)				
Earthmoving equipment (fuel and maintenance)	1,130,500 tons	0.30/ton	339,200	3.5
Electricity	5,535 kkWh	0.027/kWh	149,400	1.5
Analyses	1,500 hr	17.00/man-hr	25,500	0.3
Subtotal conversion costs			2,272,000	23.6
Subtotal direct costs			5,731,800	59.5
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			1,244,500	13.0
Average cost of capital and taxes at 8.6% of total capital investment			1,444,700	15.0
Overhead				
Plant, 50% of conversion costs less utilities			1,061,300	10.0
Administrative, 10% of operating labor			144,100	1.5
Subtotal indirect costs			3,894,600	40.5
Total annual revenue requirements			9,626,400	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	14.30	8.52	0.93	

a. Basis

Remaining plant life, 30 yr.
Coal burned, 1,285,714 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $18,313,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-231. CHEMFIX PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: disposal area 5 mi from scrubber facilities)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	3,575	35.7	17.8
Piping and insulation	229	2.3	1.1
Transport lines	3,484	34.7	17.2
Foundation and structural	216	2.1	1.1
Excavation, site preparation, roads and railroads	309	3.1	1.5
Electrical	971	9.7	4.8
Instrumentation	106	1.1	0.5
Buildings	550	5.5	2.7
Subtotal	9,440	94.2	46.7
Services and miscellaneous	142	1.4	0.7
Subtotal excluding trucks and equipment	9,582	95.6	47.4
Trucks and earthmoving equipment	442	4.4	2.2
Subtotal direct investment	10,024	100.0	49.6
Engineering design and supervision	461	4.6	2.3
Architect and engineering contractor	115	1.1	0.6
Construction expense	1,631	16.3	8.0
Contractor fees	553	5.5	2.7
Subtotal	12,784	127.5	63.2
Contingency	2,557	25.0	12.6
Subtotal fixed investment	15,341	153.0	75.8
Allowance for startup and modifications	1,490	14.9	7.4
Interest during construction	1,841	18.4	9.1
Subtotal capital investment	18,672	186.3	92.3
Land	693	6.9	3.4
Working capital	862	8.6	4.3
Total capital investment	20,227	201.8	100.0

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[a] Basis.
New 500-MW plant (30-yr life); 203 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removal.
Disposal in landfill 5 mi from scrubber facilities.
Land required for disposal, 198 acres at 30 ft deep.
Clarified sludge (35% solids) transported by pipeline to disposal/treatment area.
Fixation additives (% of dry solids): Portland cement - 7%, sodium silicate - 4%.

TABLE A-232. CHEMFIX PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: disposal over 5 mi from scrubber facilities)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Sodium silicate (38% soln)	7,357 tons	98.00/ton	721,000	8.3
Cement	28,000 tons	52.00/ton	1,456,000	16.8
Subtotal raw materials cost			2,177,000	25.1
Conversion costs				
Operating labor and supervision				
Plant	43,800 man-hr	12.50/man-hr	547,500	6.3
Solids disposal equipment	43,800 man-hr	17.00/man-hr	744,600	8.6
Maintenance--plant labor and material, 4% of direct investment			383,300	4.4
Landfill operation				
Land preparation			11,000	0.1
Trucks (fuel and maintenance)				
Earthmoving equipment (fuel and maintenance)	710,500 tons	0.30/ton	213,200	2.5
Electricity	10,078 kkWh	0.029/kWh	292,300	3.4
Analyses	1,000 hr	17.00/man-hr	17,000	0.2
Subtotal conversion costs			2,208,900	25.5
Subtotal direct costs			4,385,900	50.6
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			1,462,000	16.8
Average cost of capital and taxes at 8.6% of total capital investment			1,739,500	20.1
Overhead				
Plant, 50% of conversion costs less utilities			958,300	11.0
Administrative, 10% of operating labor			129,200	1.5
Subtotal indirect costs			4,289,000	49.4
Total annual revenue requirements			8,674,900	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	20.49	12.52	2.48

a. Basis

Remaining plant life, 30 yr.
Coal burned, 482,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment $20,227,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-233. CHEMFIX PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: disposal area 10 mi from scrubber facilities)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	3,598	26.0	13.4
Piping and insulation	225	1.6	0.9
Transport lines	6,969	50.5	26.0
Foundation and structural	216	1.6	0.8
Excavation, site preparation, roads and railroads	499	3.6	1.9
Electrical	1,008	7.3	3.8
Instrumentation	106	0.8	0.4
Buildings	550	4.0	2.0
Subtotal	13,171	95.4	49.2
Services and miscellaneous	198	1.4	0.7
Subtotal excluding trucks and equipment	13,369	96.8	49.9
Trucks and earthmoving equipment	442	3.2	1.7
Subtotal direct investment	13,811	100.0	51.6
Engineering design and supervision	461	3.3	1.7
Architect and engineering contractor	115	0.8	0.4
Construction expense	2,151	15.7	8.1
Contractor fees	706	5.1	2.6
Subtotal	17,244	124.9	64.4
Contingency	3,449	24.9	12.9
Subtotal fixed investment	20,693	149.8	77.3
Allowance for startup and modifications	2,025	14.7	7.5
Interest during construction	2,483	18.0	9.3
Subtotal capital investment	25,201	182.5	94.1
Land	693	5.0	2.6
Working capital	894	6.5	3.3
Total capital investment	26,788	194.0	100.0

[a] Basis

New 500-MW plant (30-yr life); 203 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 10 mi from scrubber facilities.
Land required for disposal, 198 acres at 30 ft deep.
Clarified sludge (35% solids) transported by pipeline to disposal/treatment area.
Fixation additives (% of dry solids): Portland cement - 7%, sodium silicate - 4%.

TABLE A-234. CHEMFIX PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: disposal area 10 mi from scrubber facilities)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Sodium silicate (38% soln)	7,357 tons	98.00/ton	721,000	7.2
Cement	28,000 tons	52.00/ton	1,456,000	14.5
Subtotal raw materials cost			2,177,000	21.7
Conversion costs				
Operating labor and supervision				
Plant	43,800 man-hr	12.50/man-hr	547,500	5.5
Solids disposal equipment	43,800 man-hr	17.00/man-hr	744,600	7.4
Maintenance--plant labor and material, 4% of direct investment			534,800	5.4
Landfill operation				
Land preparation			11,000	0.1
Trucks (fuel and maintenance)				
Earthmoving equipment (fuel and maintenance)	710,500 tons	0.30/ton	213,200	2.1
Electricity	10,340 kkWh	0.029/kWh	299,900	3.0
Analyses	1,000 hr	17.00 man-hr	17,000	0.2
Subtotal conversion costs			2,368,000	23.7
Subtotal direct costs			4,545,000	45.4
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			1,973,200	19.7
Average cost of capital and taxes at 8.6% of total capital investment			2,321,000	23.2
Overhead				
Plant, 50% of conversion costs less utilities			1,034,100	10.4
Administrative, 10% of operating labor			129,200	1.3
Subtotal indirect costs			5,457,500	54.6
Total annual revenue requirements			10,002,500	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	23.63	14.43	2.86	

a. Basis
Remaining plant life, 30 yr.
Coal burned, 482,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $26,988,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-235. CHEMFIX PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: 50% solids being pumped to filter; increased fixation additive rates)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	3,378	48.3	20.7
Piping and insulation	228	3.3	1.4
Transport lines	657	9.4	4.0
Foundation and structural	388	5.5	2.4
Excavation, site preparation, roads and railroads	163	2.3	1.0
Electrical	848	12.1	5.2
Instrumentation	107	1.5	0.7
Buildings	550	7.9	3.4
Subtotal	6,319	90.3	38.8
Services and miscellaneous	95	1.3	0.6
Subtotal excluding trucks and equipment	6,414	91.6	39.4
Trucks and earthmoving equipment	585	8.4	3.6
Subtotal direct investment	6,999	100.0	43.0
Engineering design and supervision	472	6.7	2.9
Architect and engineering contractor	118	1.7	0.7
Construction expense	1,169	16.7	7.2
Contractor fees	421	6.0	2.6
Subtotal	9,179	131.1	56.4
Contingency	1,836	26.3	11.3
Subtotal fixed investment	11,015	157.4	67.7
Allowance for startup and modifications	1,043	14.9	6.4
Interest during construction	1,322	18.9	8.1
Subtotal capital investment	13,380	191.2	82.2
Land	914	13.1	5.6
Working capital	1,976	28.2	12.2
Total capital investment	16,270	232.5	100.0

a. Basis
New 500-MW plant (30-yr life); 267 klb/hr (50% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removal.
Disposal in landfill 1 mi from scrubber facilities.
Land required for disposal, 261 acres at 30 ft deep.
Clarified sludge (35% solids) transported by pipeline to disposal/treatment area.
Fixation additives (% of dry solids): Portland cement - 22%, sodium silicate - 8%.

TABLE A-236. CHEMFIX PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 50% solids from filter)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Sodium silicate (38% soln)	35,889 tons	98.00/ton	3,517,100	25.7
Cement	88,256 tons	52.00/ton	4,589,300	33.6
Subtotal raw materials cost			8,106,400	59.3
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	3.2
Solids disposal equipment	52,560 man-hr	17.00/man-hr	893,500	6.6
Maintenance--plant labor and material, 4% of direct investment			256,600	1.9
Landfill operation				
Land preparation			15,000	0.1
Trucks (fuel and maintenance)				
Earthmoving equipment (fuel and maintenance)	934,500 tons	0.30/ton	280,400	2.1
Electricity	3,932 kkWh	0.029/kWh	114,000	0.8
Analyses	1,000 hr	17.00/man-hr	17,000	0.1
Subtotal conversion costs			2,014,500	14.8
Subtotal direct costs			10,120,900	74.1
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			1,047,700	7.7
Average cost of capital and taxes at 8.6% of total capital investment			1,399,200	10.2
Overhead				
Plant, 50% of conversion costs less utilities			950,300	7.0
Administrative, 10% of operating labor			133,200	1.0
Subtotal indirect costs			3,530,400	25.9
Total annual revenue requirements			13,651,300	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	28.71	14.61	3.90	

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a. Basis

Remaining plant life, 30 yr.
Coal burned, 482,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $16,270,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-237. CHEMFIX PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: 55% solids being pumped to filter; increased fixation additive rates)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	3,120	47.8	21.1
Piping and insulation	228	3.5	1.5
Transport lines	657	10.0	4.5
Foundation and structural	306	4.7	2.1
Excavation, site preparation, roads and railroads	162	2.5	1.1
Electrical	853	13.0	5.8
Instrumentation	107	1.6	0.7
Buildings	550	8.4	3.7
Subtotal	5,983	91.5	40.5
Services and miscellaneous	90	1.4	0.6
Subtotal excluding trucks and equipment	6,073	92.9	40.1
Trucks and earthmoving equipment	468	7.1	3.2
Subtotal direct investment	6,541	100.0	44.3
Engineering design and supervision	472	7.2	3.2
Architect and engineering contractor	118	1.8	0.8
Construction expense	1,117	17.1	7.6
Contractor fees	400	6.1	2.7
Subtotal	8,648	132.2	58.6
Contingency	1,730	26.5	11.7
Subtotal fixed investment	10,378	158.7	70.3
Allowance for startup and modifications	991	15.2	6.7
Interest during construction	1,245	18.9	8.5
Subtotal capital investment	12,614	192.8	85.5
Land	795	12.2	5.4
Working capital	1,348	20.6	9.1
Total capital investment	14,757	225.6	100.0

a. Basis
New 500-MW plant (30-yr life); 232 klb/hr (55% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities.
Land required for disposal, 227 acres at 30 ft deep.
Clarified sludge (35% solids) transported by pipeline to disposal/treatment area.
Fixation additives (% of dry solids): Portland cement - 12%, sodium silicate - 6%.

TABLE A-238. CHEMFIX PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: 55% solids from filter)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Sodium silicate (38% soln)	24,843 tons	98.00/ton	2,434,600	24.1
Cement	50,313 tons	52.00/ton	2,616,300	25.9
Subtotal raw materials cost			5,050,900	50.0
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	4.4
Solids disposal equipment	43,800 man-hr	17.00/man-hr	744,600	7.4
Maintenance--plant labor and material, 4% of direct investment			242,900	2.4
Landfill operation				
Land preparation			13,000	0.1
Trucks (fuel and maintenance)				
Earthmoving equipment (fuel and maintenance)	812,000 tons	0.30/ton	243,600	2.4
Electricity	3,953 kkWh	0.029/kWh	114,600	1.1
Analyses	1,000 hr	17.00/man-hr	17,000	0.2
Subtotal conversion costs			1,813,700	18.0
Subtotal direct costs			6,864,600	68.0
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			987,700	9.8
Average cost of capital and taxes at 8.6% of total capital investment			1,269,100	12.6
Overhead				
Plant, 50% of conversion costs less utilities			849,600	8.4
Administrative, 10% of operating labor			118,300	1.2
Subtotal indirect costs			3,224,700	32.0
Total annual revenue requirements			10,089,300	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	20.99	12.42	2.89

[a] Basis

Remaining plant life, 30 yr.
Coal burned, 482,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment $14,757,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-239. CHEMFIX PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: lime process with 1.1 stoichiometry)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,542	44.4	20.5
Piping and insulation	219	3.8	1.8
Transport lines	657	11.5	5.3
Foundation and structural	243	4.2	1.9
Excavation, site preparation, roads and railroads	164	2.9	1.3
Electrical	727	12.7	5.9
Instrumentation	103	1.8	0.8
Buildings	550	9.6	4.4
Subtotal	5,205	90.9	41.9
Services and miscellaneous	78	1.4	0.6
Subtotal excluding trucks and equipment	5,283	92.3	42.5
Trucks and earthmoving equipment	441	7.7	3.6
Subtotal direct investment	5,724	100.0	46.1
Engineering design and supervision	449	7.8	3.6
Architect and engineering contractor	112	2.0	0.9
Construction expense	995	17.4	8.0
Contractor fees	362	6.3	2.9
Subtotal	7,642	133.5	61.5
Contingency	1,528	26.7	12.3
Subtotal fixed investment	9,170	160.2	73.8
Allowance for startup and modifications	873	15.3	7.0
Interest during construction	1,100	19.2	8.8
Subtotal capital investment	11,143	194.7	89.6
Land	606	10.6	4.9
Working capital	682	11.9	5.5
Total capital investment	12,431	217.2	100.0

a. Basis
New 500-MW plant (30-yr life); 177 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Lime process with 1.1 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities.
Land required for disposal, 173 acres at 30 ft deep.
Clarified sludge (35% solids) transported by pipeline to disposal/treatment area.
Fixation additives (% of dry solids): Portland cement - 7%, sodium silicate - 4%.

TABLE A-240. CHEMFIX PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: lime process with 1.1 stoichiometry)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Sodium silicate (38% soln)	6,412 tons	98.00/ton	628,400	10.1
Cement	24,332 tons	52.00/ton	1,265,300	20.4
Subtotal raw materials cost			1,893,700	30.5
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	7.1
Solids disposal equipment	43,800 man-hr	17.00/man-hr	744,600	12.0
Maintenance--plant labor and material, 4% of direct investment			211,300	3.4
Landfill operation				
Land preparation			10,000	0.1
Trucks (fuel and maintenance)				
Earthmoving equipment (fuel and maintenance)	619,500 tons	0.30/ton	11,200	0.2
Electricity	3,368 kkWh	0.029/kWh	97,700	1.6
Analyses	1,000 hr	17.00/man-hr	17,000	0.3
Subtotal conversion costs			1,529,800	24.7
Subtotal direct costs			3,423,500	55.2
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			872,500	14.1
Average cost of capital and taxes at 8.6% of total capital investment			1,069,100	17.2
Overhead				
Plant, 50% of conversion costs less utilities			716,100	11.6
Administrative, 10% of operating labor			118,300	1.9
Subtotal indirect costs			2,776,000	44.8
Total annual revenue requirements			6,199,500	100.0

	Dollars/dry ton	Dollars/wet ton	Mills/kWh
Equivalent unit revenue requirements	16.83	10.01	1.77

a. Basis
Remaining plant life, 30 yr.
Coal burned, 482,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $12,431,000.
Midwest plant location, mid-1980 operating costs.

TABLE A-241. CHEMFIX PROCESS[a]

TOTAL CAPITAL INVESTMENT - PROCESS EQUIPMENT AND INSTALLATION ANALYSIS

(Variation from base case: Trucks used for transport of treated sludge to disposal area)

	Total, k$	Percent of direct investment	Percent of total capital investment
Process equipment	2,813	54.0	23.9
Piping and insulation	207	4.0	1.8
Transport lines	-	-	-
Foundation and structural	211	4.1	1.8
Excavation, site preparation, roads and railroads	117	2.2	1.0
Electrical	725	13.9	6.2
Instrumentation	92	1.8	0.8
Buildings	550	10.5	4.7
Subtotal	4,715	90.5	40.2
Services and miscellaneous	71	1.4	0.6
Subtotal excluding trucks and equipment	4,786	91.9	40.8
Trucks and earthmoving equipment	423	8.1	3.6
Subtotal direct investment	5,209	100.0	44.4
Engineering design and supervision	461	8.9	3.9
Architect and engineering contractor	115	2.2	1.0
Construction expense	917	17.5	7.8
Contractor fees	337	6.5	2.9
Subtotal	7,039	135.1	60.0
Contingency	1,408	27.1	12.0
Subtotal fixed investment	8,447	162.2	72.0
Allowance for startup and modifications	802	15.4	6.8
Interest during construction	1,014	19.4	8.6
Subtotal capital investment	10,263	197.0	87.4
Land	693	13.3	5.9
Working capital	784	15.1	6.7
Total capital investment	11,740	225.4	100.0

a. Basis

New 500-MW plant (30-yr life); 203 klb/hr (60% solids) sludge.
Midwest plant location; average basis for cost scaling, mid-1979.
Coal analysis (by wt): 3.5% S (dry basis), 16% ash.
Flyash removed with SO_2.
SO_2 and flyash removed to meet NSPS.
Limestone process with 1.5 stoichiometry based on SO_2 removed.
Disposal in landfill 1 mi from scrubber facilities.
Land required for disposal, 198 acres at 30 ft deep.
Trucks used for transport of treated sludge to disposal area.
Fixation additives (% of dry solids): Portland cement - 7%, sodium silicate - 4%.

TABLE A-242. CHEMFIX PROCESS[a]

TOTAL ANNUAL REVENUE REQUIREMENTS - REGULATED UTILITY ECONOMICS

(Variation from base case: intermediate ponding, transport by truck)

	Annual quantity	Unit cost, $	Total annual revenue requirements, $	Percent of total annual revenue requirements
Direct costs				
Delivered raw materials				
Sodium silicate (38% soln)	7,357 tons	98.00/ton	721,000	10.8
Cement	28,000 tons	52.00/ton	1,456,000	21.7
Subtotal raw materials cost			2,177,000	32.5
Conversion costs				
Operating labor and supervision				
Plant	35,040 man-hr	12.50/man-hr	438,000	6.5
Solids disposal equipment	43,800 man-hr	17.00/man-hr	744,600	11.1
Maintenance--plant labor and material, 4% of direct investment			191,400	2.9
Landfill operation				
Land preparation			11,000	0.2
Trucks (fuel and maintenance)	710,500 tons	0.06/ton	42,600	0.6
Earthmoving equipment (fuel and maintenance)	710,500 tons	0.30/ton	213,200	3.2
Electricity	3,551 kkWh	0.029/kWh	103,000	1.5
Analyses	1,000 hr	17.00/man-hr	17,000	0.3
Subtotal conversion costs			1,760,800	26.3
Subtotal direct costs			3,937,800	58.8
Indirect costs				
Capital charges				
Depreciation, interim replacement, and insurance at 7.83% of total capital investment less land and working capital			803,600	12.0
Average cost of capital and taxes at 8.6% of total capital investment			1,009,600	15.0
Overhead				
Plant, 50% of conversion costs less utilities			828,900	12.4
Administrative, 10% of operating labor			118,300	1.8
Subtotal indirect costs			2,760,400	41.2
Total annual revenue requirements			6,698,200	100.0
	Dollars/dry ton	Dollars/wet ton	Mills/kWh	
Equivalent unit revenue requirements	15.82	9.66	1.91	

[a] Basis

Remaining plant life, 30 yr.
Coal burned, 482,571 lb/hr, 9,000 Btu/kWh.
Power plant on-stream time, 7,000 hr/yr.
Total capital investment, $11,740,000.
Midwest plant location, mid-1980 operating costs.

APPENDIX B

DECLINING OPERATING PROFILE - LIFETIME REVENUE REQUIREMENTS

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TABLE B-1

LIME/LIMESTONE SLUDGE DISPOSAL - UNTREATED, 200 MW NEW UNIT, 3.5% S, 16% ASH IN COAL, REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 9800000

YEARS AFTER POWER UNIT START	ANNUAL OPERA-TION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	7000	12880000	613300	14600	332500	0.0	2881000	0	2881000	2881000
2	7000	12880000	613300	14600	332500	0.0	2829400	0	2829400	5710400
3	7000	12880000	613300	14600	332500	0.0	2777700	0	2777700	8488100
4	7000	12880000	613300	14600	332500	0.0	2726100	0	2726100	11214200
5	7000	12880000	613300	14600	332500	0.0	2674500	0	2674500	13888700
6	7000	12880000	613300	14600	332500	0.0	2622800	0	2622800	16511500
7	7000	12880000	613300	14600	332500	0.0	2571200	0	2571200	19082700
8	7000	12880000	613300	14600	332500	0.0	2519600	0	2519600	21602300
9	7000	12880000	613300	14600	332500	0.0	2467900	0	2467900	24070200
10	7000	12880000	613300	14600	332500	0.0	2416300	0	2416300	26486500
11	5000	9200000	438100	10400	237500	0.0	2255100	0	2255100	28741600
12	5000	9200000	438100	10400	237500	0.0	2203400	0	2203400	30945000
13	5000	9200000	438100	10400	237500	0.0	2151800	0	2151800	33096800
14	5000	9200000	438100	10400	237500	0.0	2100200	0	2100200	35197000
15	5000	9200000	438100	10400	237500	0.0	2048500	0	2048500	37245500
16	3500	6440000	306700	7300	166300	0.0	1902100	0	1902100	39147600
17	3500	6440000	306700	7300	166300	0.0	1850400	0	1850400	40998000
18	3500	6440000	306700	7300	166300	0.0	1798800	0	1798800	42796800
19	3500	6440000	306700	7300	166300	0.0	1747200	0	1747200	44544000
20	3500	6440000	306700	7300	166300	0.0	1695500	0	1695500	46239500
21	1500	2760000	131400	3100	71300	0.0	1483400	0	1483400	47722900
22	1500	2760000	131400	3100	71300	0.0	1431800	0	1431800	49154700
23	1500	2760000	131400	3100	71300	0.0	1380100	0	1380100	50534800
24	1500	2760000	131400	3100	71300	0.0	1328500	0	1328500	51863300
25	1500	2760000	131400	3100	71300	0.0	1276900	0	1276900	53140200
26	1500	2760000	131400	3100	71300	0.0	1225200	0	1225200	54365400
27	1500	2760000	131400	3100	71300	0.0	1173600	0	1173600	55539000
28	1500	2760000	131400	3100	71300	0.0	1122000	0	1122000	56661000
29	1500	2760000	131400	3100	71300	0.0	1070300	0	1070300	57731300
30	1500	2760000	131400	3100	71300	0.0	1018700	0	1018700	58750000
TOT	127500	234600000	11171000	265500	6057000		58750000	0	58750000	
LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST										
DOLLARS PER TON OF COAL BURNED							5.26	0.0	5.26	
MILLS PER KILOWATT-HOUR							2.30	0.0	2.30	
CENTS PER MILLION BTU HEAT INPUT							25.04	0.0	25.04	
DOLLARS PER TON OF SULFUR REMOVED							221.28	0.0	221.28	
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS							20204800	0	20204800	
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT										
DOLLARS PER TON OF COAL BURNED							4.64	0.0	4.64	
MILLS PER KILOWATT-HOUR							2.03	0.0	2.03	
CENTS PER MILLION BTU HEAT INPUT							22.10	0.0	22.10	
DOLLARS PER TON OF SULFUR REMOVED							195.03	0.0	195.03	

TABLE B-2

LIME/LIMESTONE SLUDGE DISPOSAL - UNTREATED, 500 MW NEW UNIT, 3.5% S, 16% ASH IN COAL, REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 17211000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	7000	31500000	1500000	35600	812000	0.0	4807200	0	4807200	4807200
2	7000	31500000	1500000	35600	812000	0.0	4717300	0	4717300	9524500
3	7000	31500000	1500000	35600	812000	0.0	4627500	0	4627500	14152000
4	7000	31500000	1500000	35600	812000	0.0	4537600	0	4537600	18689600
5	7000	31500000	1500000	35600	812000	0.0	4447800	0	4447800	23137600
6	7000	31500000	1500000	35600	812000	0.0	4357900	0	4357900	27495300
7	7000	31500000	1500000	35600	812000	0.0	4268100	0	4268100	31763400
8	7000	31500000	1500000	35600	812000	0.0	4178200	0	4178200	35941600
9	7000	31500000	1500000	35600	812000	0.0	4088400	0	4088400	40030000
10	7000	31500000	1500000	35600	812000	0.0	3998500	0	3998500	44028500
11	5000	22500000	1071400	25400	580000	0.0	3751600	0	3751600	47780100
12	5000	22500000	1071400	25400	580000	0.0	3661700	0	3661700	51441800
13	5000	22500000	1071400	25400	580000	0.0	3571900	0	3571900	55013700
14	5000	22500000	1071400	25400	580000	0.0	3482000	0	3482000	58495700
15	5000	22500000	1071400	25400	580000	0.0	3392200	0	3392200	61887900
16	3500	15750000	750000	17800	406000	0.0	3168300	0	3168300	65056200
17	3500	15750000	750000	17800	406000	0.0	3078400	0	3078400	68134600
18	3500	15750000	750000	17800	406000	0.0	2988600	0	2988600	71123200
19	3500	15750000	750000	17800	406000	0.0	2898700	0	2898700	74021900
20	3500	15750000	750000	17800	406000	0.0	2808900	0	2808900	76830800
21	1500	6750000	321400	7600	174000	0.0	2497000	0	2497000	79327800
22	1500	6750000	321400	7600	174000	0.0	2407200	0	2407200	81735000
23	1500	6750000	321400	7600	174000	0.0	2317300	0	2317300	84052300
24	1500	6750000	321400	7600	174000	0.0	2227500	0	2227500	86279800
25	1500	6750000	321400	7600	174000	0.0	2137600	0	2137600	88617400
26	1500	6750000	321400	7600	174000	0.0	2047800	0	2047800	90465200
27	1500	6750000	321400	7600	174000	0.0	1957900	0	1957900	92423100
28	1500	6750000	321400	7600	174000	0.0	1868100	0	1868100	94291200
29	1500	6750000	321400	7600	174000	0.0	1778200	0	1778200	96069400
30	1500	6750000	321400	7600	174000	0.0	1688400	0	1688400	97757800
TOT	127500	573750000	27321000	648000	14790000		97757800	0	97757800	

LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST			
DOLLARS PER TON OF COAL BURNED	3.58	0.0	3.58
MILLS PER KILOWATT-HOUR	1.53	0.0	1.53
CENTS PER MILLION BTU HEAT INPUT	17.04	0.0	17.04
DOLLARS PER TON OF SULFUR REMOVED	150.86	0.0	150.86
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS	33612100	0	33612100
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT			
DOLLARS PER TON OF COAL BURNED	3.16	0.0	3.16
MILLS PER KILOWATT-HOUR	1.35	0.0	1.35
CENTS PER MILLION BTU HEAT INPUT	15.03	0.0	15.03
DOLLARS PER TON OF SULFUR REMOVED	133.01	0.0	133.01

TABLE B-3

LIME/LIMESTONE SLUDGE DISPOSAL - UNTREATED, 1500 MW NEW UNIT, 3.5% S, 16% ASH IN COAL, REGULATED CO. ECONOMICS.

FIXED INVESTMENT: $ 36455000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	7000	94500000	4500000	106800	2432500	0.0	9988400	0	9988400	9988400
2	7000	94500000	4500000	106800	2432500	0.0	9799900	0	9799900	19788300
3	7000	94500000	4500000	106800	2432500	0.0	9611400	0	9611400	29399700
4	7000	94500000	4500000	106800	2432500	0.0	9422900	0	9422900	38822600
5	7000	94500000	4500000	106800	2432500	0.0	9234400	0	9234400	48057000
6	7000	94500000	4500000	106800	2432500	0.0	9045900	0	9045900	57102900
7	7000	94500000	4500000	106800	2432500	0.0	8857400	0	8857400	65960300
8	7000	94500000	4500000	106800	2432500	0.0	8668900	0	8668900	74629200
9	7000	94500000	4500000	106800	2432500	0.0	8480400	0	8480400	83109600
10	7000	94500000	4500000	106800	2432500	0.0	8291900	0	8291900	91401500
11	5000	67500000	3214300	76300	1737500	0.0	7794800	0	7794800	99196300
12	5000	67500000	3214300	76300	1737500	0.0	7606300	0	7606300	106802600
13	5000	67500000	3214300	76300	1737500	0.0	7417800	0	7417800	114220400
14	5000	67500000	3214300	76300	1737500	0.0	7229300	0	7229300	121449700
15	5000	67500000	3214300	76300	1737500	0.0	7040800	0	7040800	128490500
16	3500	47250000	2250000	53400	1216300	0.0	6591600	0	6591600	135082100
17	3500	47250000	2250000	53400	1216300	0.0	6403100	0	6403100	141485200
18	3500	47250000	2250000	53400	1216300	0.0	6214600	0	6214600	147699800
19	3500	47250000	2250000	53400	1216300	0.0	6026200	0	6026200	153726000
20	3500	47250000	2250000	53400	1216300	0.0	5837700	0	5837700	159563700
21	1500	20250000	964300	22900	521300	0.0	5222800	0	5222800	164786500
22	1500	20250000	964300	22900	521300	0.0	5034300	0	5034300	169820800
23	1500	20250000	964300	22900	521300	0.0	4845800	0	4845800	174666600
24	1500	20250000	964300	22900	521300	0.0	4657300	0	4657300	179323900
25	1500	20250000	964300	22900	521300	0.0	4468800	0	4468800	183792700
26	1500	20250000	964300	22900	521300	0.0	4280300	0	4280300	188073000
27	1500	20250000	964300	22900	521300	0.0	4091800	0	4091800	192164800
28	1500	20250000	964300	22900	521300	0.0	3903300	0	3903300	196068100
29	1500	20250000	964300	22900	521300	0.0	3714800	0	3714800	199782900
30	1500	20250000	964300	22900	521300	0.0	3526300	0	3526300	203309200
TOT	127500	1721250000	81964500	1945500	44307000		203309200	0	203309200	
LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST										
DOLLARS PER TON OF COAL BURNED							2.48	0.0	2.48	
MILLS PER KILOWATT-HOUR							1.06	0.0	1.06	
CENTS PER MILLION BTU HEAT INPUT							11.81	0.0	11.81	
DOLLARS PER TON OF SULFUR REMOVED							104.50	0.0	104.50	
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS							69819400	0	69819400	
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT										
DOLLARS PER TON OF COAL BURNED							2.19	0.0	2.19	
MILLS PER KILOWATT-HOUR							0.94	0.0	0.94	
CENTS PER MILLION BTU HEAT INPUT							10.41	0.0	10.41	
DOLLARS PER TON OF SULFUR REMOVED							92.07	0.0	92.07	

TABLE B-4

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LIME/LIMESTONE SLUDGE DISPOSAL - DRAVO PROCESS, 200 MW NEW UNIT, 3.5% S, 16% ASH IN COAL, REGULATED CO. ECONOMICS

                                          FIXED INVESTMENT:  $   13942000
                                                                                        TOTAL
                                                                                       OP. COST
                                              SULFUR       BY-PRODUCT                  INCLUDING                 NET ANNUAL    CUMULATIVE
                                              REMOVED        RATE,                     REGULATED                  INCREASE    NET INCREASE
YEARS ANNUAL  POWER UNIT    POWER UNIT          BY         EQUIVALENT   NET REVENUE,   ROI FOR       TOTAL       (DECREASE)    (DECREASE)
AFTER OPERA-     HEAT          FUEL          POLLUTION     TONS/YEAR      $/TON         POWER         NET        IN COST OF    IN COST OF
POWER TION,   REQUIREMENT, CONSUMPTION,       CONTROL                                  COMPANY,      SALES         POWER,        POWER,
UNIT  KW-HR/  MILLION BTU    TONS COAL        PROCESS,       WASTE        WASTE        $/YEAR      REVENUE,         $             $
START   KW       /YEAR         /YEAR         TONS/YEAR       SOLIDS       SOLIDS                   $/YEAR
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  1    7000    12880000       613300          14600         357000         0.0         4773900          0       4773900       4773900
  2    7000    12880000       613300          14600         357000         0.0         4699400          0       4699400       9473300
  3    7000    12880000       613300          14600         357000         0.0         4624800          0       4624800      14098100
  4    7000    12880000       613300          14600         357000         0.0         4550300          0       4550300      18648400
__5____7000____12880000_______613300__________14600_________357000_________0.0_________4475700__________0_______4475700______23124100
  6    7000    12880000       613300          14600         357000         0.0         4401200          0       4401200      27525300
  7    7000    12880000       613300          14600         357000         0.0         4326700          0       4326700      31852000
  8    7000    12880000       613300          14600         357000         0.0         4252100          0       4252100      36104100
  9    7000    12880000       613300          14600         357000         0.0         4177600          0       4177600      40281700
_10____7000____12880000_______613300__________14600_________357000_________0.0_________4103000__________0_______4103000______44384700
 11    5000     9200000       438100          10400         255000         0.0         3655300          0       3655300      48040000
 12    5000     9200000       438100          10400         255000         0.0         3580700          0       3580700      51620700
 13    5000     9200000       438100          10400         255000         0.0         3506200          0       3506200      55126900
 14    5000     9200000       438100          10400         255000         0.0         3431600          0       3431600      58558500
_15____5000_____9200000_______438100__________10400_________255000_________0.0_________3357100__________0_______3357100______61915600
 16    3500     6440000       306700           7300         178500         0.0         2984700          0       2984700      64900300
 17    3500     6440000       306700           7300         178500         0.0         2910100          0       2910100      67810400
 18    3500     6440000       306700           7300         178500         0.0         2835600          0       2835600      70646000
 19    3500     6440000       306700           7300         178500         0.0         2761000          0       2761000      73407000
_20____3500_____6440000_______306700___________7300_________178500_________0.0_________2686500__________0_______2686500______76093500
 21    1500     2760000       131400           3100          76500         0.0         2165300          0       2165300      78258800
 22    1500     2760000       131400           3100          76500         0.0         2090800          0       2090800      80349600
 23    1500     2760000       131400           3100          76500         0.0         2016200          0       2016200      82365800
 24    1500     2760000       131400           3100          76500         0.0         1941700          0       1941700      84307500
_25____1500_____2760000_______131400___________3100__________76500_________0.0_________1867100__________0_______1867100______86174600
 26    1500     2760000       131400           3100          76500         0.0         1792600          0       1792600      87967200
 27    1500     2760000       131400           3100          76500         0.0         1718100          0       1718100      89685300
 28    1500     2760000       131400           3100          76500         0.0         1643500          0       1643500      91328800
 29    1500     2760000       131400           3100          76500         0.0         1569000          0       1569000      92897800
_30____1500_____2760000_______131400___________3100__________76500_________0.0_________1494600__________0_______1494600______94392200

TOT  127500   234600000     11171000         265500        6502500                    94392200          0      94392200
   LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST
                     DOLLARS PER TON OF COAL BURNED                                       8.45        0.0          8.45
                     MILLS PER KILOWATT-HOUR                                              3.70        0.0          3.70
                     CENTS PER MILLION BTU HEAT INPUT                                    40.24        0.0         40.24
                     DOLLARS PER TON OF SULFUR REMOVED                                  355.53        0.0        355.53
PROCESS COST DISCOUNTED AT  11.6% TO INITIAL YEAR, DOLLARS                            33368200          0      33368200
   LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT
                     DOLLARS PER TON OF COAL BURNED                                       7.66        0.0          7.66
                     MILLS PER KILOWATT-HOUR                                              3.36        0.0          3.36
                     CENTS PER MILLION BTU HEAT INPUT                                    36.49        0.0         36.49
                     DOLLARS PER TON OF SULFUR REMOVED                                  322.09        0.0        322.09

DATA SETUP NEEDS CHECKING.

XHEAD CARD IS INCORRECT OR ORDER OF SETUP IS INCORRECT.
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TABLE B-5

LIME/LIMESTONE SLUDGE DISPOSAL - DRAVO PROCESS, 500 MW, NEW UNIT, 3.5% S, 16% ASH IN COAL, REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 24114000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	7000	31500000	1500000	35600	875000	0.0	8835600	0	8835600	8835600
2	7000	31500000	1500000	35600	875000	0.0	8708800	0	8708800	17544400
3	7000	31500000	1500000	35600	875000	0.0	8582000	0	8582000	26126400
4	7000	31500000	1500000	35600	875000	0.0	8455300	0	8455300	34581700
5	7000	31500000	1500000	35600	875000	0.0	8328500	0	8328500	42910200
6	7000	31500000	1500000	35600	875000	0.0	8201700	0	8201700	51111900
7	7000	31500000	1500000	35600	875000	0.0	8074900	0	8074900	59186800
8	7000	31500000	1500000	35600	875000	0.0	7948100	0	7948100	67134900
9	7000	31500000	1500000	35600	875000	0.0	7821400	0	7821400	74956300
10	7000	31500000	1500000	35600	875000	0.0	7694600	0	7694600	82650900
11	5000	22500000	1071400	25400	625000	0.0	6776300	0	6776300	89427200
12	5000	22500000	1071400	25400	625000	0.0	6649500	0	6649500	96076700
13	5000	22500000	1071400	25400	625000	0.0	6522700	0	6522700	102599400
14	5000	22500000	1071400	25400	625000	0.0	6396000	0	6396000	108995400
15	5000	22500000	1071400	25400	625000	0.0	6269200	0	6269200	115264600
16	3500	15750000	750000	17800	437500	0.0	5521500	0	5521500	120786100
17	3500	15750000	750000	17800	437500	0.0	5394700	0	5394700	126180800
18	3500	15750000	750000	17800	437500	0.0	5267900	0	5267900	131448700
19	3500	15750000	750000	17800	437500	0.0	5141100	0	5141100	136589800
20	3500	15750000	750000	17800	437500	0.0	5014600	0	5014600	141604200
21	1500	6750000	321400	7600	187500	0.0	3986600	0	3986600	145590800
22	1500	6750000	321400	7600	187500	0.0	3859800	0	3859800	149450600
23	1500	6750000	321400	7600	187500	0.0	3733000	0	3733000	153183600
24	1500	6750000	321400	7600	187500	0.0	3606200	0	3606200	156789800
25	1500	6750000	321400	7600	187500	0.0	3479500	0	3479500	160269300
26	1500	6750000	321400	7600	187500	0.0	3352700	0	3352700	163622000
27	1500	6750000	321400	7600	187500	0.0	3225900	0	3225900	166847900
28	1500	6750000	321400	7600	187500	0.0	3099100	0	3099100	169947000
29	1500	6750000	321400	7600	187500	0.0	2972300	0	2972300	172919300
30	1500	6750000	321400	7600	187500	0.0	2845600	0	2845600	175764900
TOT	127500	573750000	27321000	648000	15937500		175764900	0	175764900	
LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST										
DOLLARS PER TON OF COAL BURNED							6.43	0.0	6.43	
MILLS PER KILOWATT-HOUR							2.76	0.0	2.76	
CENTS PER MILLION BTU HEAT INPUT							30.63	0.0	30.63	
DOLLARS PER TON OF SULFUR REMOVED							271.24	0.0	271.24	
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS							62052600	0	62052600	
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT										
DOLLARS PER TON OF COAL BURNED							5.83	0.0	5.83	
MILLS PER KILOWATT-HOUR							2.50	0.0	2.50	
CENTS PER MILLION BTU HEAT INPUT							27.75	0.0	27.75	
DOLLARS PER TON OF SULFUR REMOVED							245.56	0.0	245.56	

TABLE B-6

LIME/LIMESTONE SLUDGE DISPOSAL - DRAVO PROCESS, 1500 MW NEW UNIT 3.5% S, 16% ASH IN COAL, REGULATED CO. ECONOMICS

FIXED INVESTMENT, $ 48235000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	7000	94500000	4500000	106800	2625000	0.0	18986900	0	18986900	18986900
2	7000	94500000	4500000	106800	2625000	0.0	18737900	0	18737900	37724800
3	7000	94500000	4500000	106800	2625000	0.0	18488900	0	18488900	56213700
4	7000	94500000	4500000	106800	2625000	0.0	18239900	0	18239900	74453600
5	7000	94500000	4500000	106800	2625000	0.0	17990800	0	17990800	92444400
6	7000	94500000	4500000	106800	2625000	0.0	17741800	0	17741800	110186200
7	7000	94500000	4500000	106800	2625000	0.0	17492800	0	17492800	127679000
8	7000	94500000	4500000	106800	2625000	0.0	17243800	0	17243800	144922800
9	7000	94500000	4500000	106800	2625000	0.0	16994700	0	16994700	161917500
10	7000	94500000	4500000	106800	2625000	0.0	16745700	0	16745700	178663200
11	5000	67500000	3214300	76300	1875000	0.0	14462200	0	14462200	193125400
12	5000	67500000	3214300	76300	1875000	0.0	14213200	0	14213200	207338600
13	5000	67500000	3214300	76300	1875000	0.0	13964200	0	13964200	221302800
14	5000	67500000	3214300	76300	1875000	0.0	13715100	0	13715100	235017900
15	5000	67500000	3214300	76300	1875000	0.0	13466100	0	13466100	248484000
16	3500	47250000	2250000	53400	1312500	0.0	11648600	0	11648600	260132600
17	3500	47250000	2250000	53400	1312500	0.0	11399600	0	11399600	271532200
18	3500	47250000	2250000	53400	1312500	0.0	11150600	0	11150600	282682800
19	3500	47250000	2250000	53400	1312500	0.0	10901500	0	10901500	293584300
20	3500	47250000	2250000	53400	1312500	0.0	10652500	0	10652500	304236800
21	1500	20250000	964300	22900	562500	0.0	8197200	0	8197200	312434000
22	1500	20250000	964300	22900	562500	0.0	7948200	0	7948200	320382200
23	1500	20250000	964300	22900	562500	0.0	7699100	0	7699100	328081300
24	1500	20250000	964300	22900	562500	0.0	7450100	0	7450100	335531400
25	1500	20250000	964300	22900	562500	0.0	7201100	0	7201100	342732500
26	1500	20250000	964300	22900	562500	0.0	6952100	0	6952100	349684600
27	1500	20250000	964300	22900	562500	0.0	6703100	0	6703100	356387700
28	1500	20250000	964300	22900	562500	0.0	6454000	0	6454000	362841700
29	1500	20250000	964300	22900	562500	0.0	6205000	0	6205000	369046700
30	1500	20250000	964300	22900	562500	0.0	5956000	0	5956000	375002700
TOT	127500	1721250000	81964500	1945500	47812500		375002700	0	375002700	
LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST										
DOLLARS PER TON OF COAL BURNED							4.58	0.0	4.58	
MILLS PER KILOWATT-HOUR							1.96	0.0	1.96	
CENTS PER MILLION BTU HEAT INPUT							21.79	0.0	21.79	
DOLLARS PER TON OF SULFUR REMOVED							192.75	0.0	192.75	
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS							133456200	0	133456200	
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT										
DOLLARS PER TON OF COAL BURNED							4.18	0.0	4.18	
MILLS PER KILOWATT-HOUR							1.79	0.0	1.79	
CENTS PER MILLION BTU HEAT INPUT							19.89	0.0	19.89	
DOLLARS PER TON OF SULFUR REMOVED							175.99	0.0	175.99	

TABLE B-7

LIME/LIMESTONE SLUDGE DISPOSAL-IUCS PROCESS, 200 MW NEW UNIT, 3.5% S, 16% ASH IN COAL REGULATED CO. ECONOMICS.

FIXED INVESTMENT: $ 7193000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	7000	12880000	613300	14600	283500	0.0	4216000	0	4216000	4216000
2	7000	12880000	613300	14600	283500	0.0	4178400	0	4178400	8394400
3	7000	12880000	613300	14600	283500	0.0	4140700	0	4140700	12535100
4	7000	12880000	613300	14600	283500	0.0	4103100	0	4103100	16638200
5	7000	12880000	613300	14600	283500	0.0	4065500	0	4065500	20703700
6	7000	12880000	613300	14600	283500	0.0	4027800	0	4027800	24731500
7	7000	12880000	613300	14600	283500	0.0	3990200	0	3990200	28721700
8	7000	12880000	613300	14600	283500	0.0	3952600	0	3952600	32674300
9	7000	12880000	613300	14600	283500	0.0	3914900	0	3914900	36589200
10	7000	12880000	613300	14600	283500	0.0	3877300	0	3877300	40466500
11	5000	9200000	438100	10400	202500	0.0	3383000	0	3383000	43849500
12	5000	9200000	438100	10400	202500	0.0	3345300	0	3345300	47194800
13	5000	9200000	438100	10400	202500	0.0	3307700	0	3307700	50502500
14	5000	9200000	438100	10400	202500	0.0	3270100	0	3270100	53772600
15	5000	9200000	438100	10400	202500	0.0	3232400	0	3232400	57005000
16	3500	6440000	306700	7300	141800	0.0	2811700	0	2811700	59816700
17	3500	6440000	306700	7300	141800	0.0	2774100	0	2774100	62590800
18	3500	6440000	306700	7300	141800	0.0	2736400	0	2736400	65327200
19	3500	6440000	306700	7300	141800	0.0	2698800	0	2698800	68026000
20	3500	6440000	306700	7300	141800	0.0	2661200	0	2661200	70687200
21	1500	2760000	131400	3100	60800	0.0	2001900	0	2001900	72689100
22	1500	2760000	131400	3100	60800	0.0	1964300	0	1964300	74653400
23	1500	2760000	131400	3100	60800	0.0	1926700	0	1926700	76580100
24	1500	2760000	131400	3100	60800	0.0	1889000	0	1889000	78469100
25	1500	2760000	131400	3100	60800	0.0	1851600	0	1851600	80320500
26	1500	2760000	131400	3100	60800	0.0	1813800	0	1813800	82134300
27	1500	2760000	131400	3100	60800	0.0	1776100	0	1776100	83910400
28	1500	2760000	131400	3100	60800	0.0	1738500	0	1738500	85648900
29	1500	2760000	131400	3100	60800	0.0	1700900	0	1700900	87349800
30	1500	2760000	131400	3100	60800	0.0	1663200	0	1663200	89013000
TOT	127500	234600000	11171000	265500	5164500		89013000	0	89013000	
LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST										
DOLLARS PER TON OF COAL BURNED							7.97	0.0	7.97	
MILLS PER KILOWATT-HOUR							3.49	0.0	3.49	
CENTS PER MILLION BTU HEAT INPUT							37.94	0.0	37.94	
DOLLARS PER TON OF SULFUR REMOVED							335.27	0.0	335.27	
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS							30584100	0	30584100	
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT										
DOLLARS PER TON OF COAL BURNED							7.02	0.0	7.02	
MILLS PER KILOWATT-HOUR							3.08	0.0	3.08	
CENTS PER MILLION BTU HEAT INPUT							33.45	0.0	33.45	
DOLLARS PER TON OF SULFUR REMOVED							295.21	0.0	295.21	

TABLE B-8

LIME/LIMESTONE SLUDGE DISPOSAL - IUCS PROCESS, 500 MW NEW UNIT, 3.5% S, 16% ASH IN COAL, REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 10717000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	7000	31500000	1500000	35600	693000	0.0	6271000	0	6271000	6271000
2	7000	31500000	1500000	35600	693000	0.0	6216500	0	6216500	12487500
3	7000	31500000	1500000	35600	693000	0.0	6162000	0	6162000	18649500
4	7000	31500000	1500000	35600	693000	0.0	6107600	0	6107600	24757100
5	7000	31500000	1500000	35600	693000	0.0	6053100	0	6053100	30810200
6	7000	31500000	1500000	35600	693000	0.0	5998600	0	5998600	36808800
7	7000	31500000	1500000	35600	693000	0.0	5944100	0	5944100	42752900
8	7000	31500000	1500000	35600	693000	0.0	5889600	0	5889600	48642500
9	7000	31500000	1500000	35600	693000	0.0	5835100	0	5835100	54477600
10	7000	31500000	1500000	35600	693000	0.0	5780600	0	5780600	60258200
11	5000	22500000	1071400	25400	495000	0.0	4989800	0	4989800	65248000
12	5000	22500000	1071400	25400	495000	0.0	4935300	0	4935300	70183300
13	5000	22500000	1071400	25400	495000	0.0	4880800	0	4880800	75064100
14	5000	22500000	1071400	25400	495000	0.0	4826400	0	4826400	79890500
15	5000	22500000	1071400	25400	495000	0.0	4771900	0	4771900	84662400
16	3500	15750000	750000	17800	346500	0.0	4114300	0	4114300	88776700
17	3500	15750000	750000	17800	346500	0.0	4059800	0	4059800	92836500
18	3500	15750000	750000	17800	346500	0.0	4005300	0	4005300	96841800
19	3500	15750000	750000	17800	346500	0.0	3950800	0	3950800	100792600
20	3500	15750000	750000	17800	346500	0.0	3896300	0	3896300	104688900
21	1500	6750000	321400	7600	148500	0.0	2898700	0	2898700	107587600
22	1500	6750000	321400	7600	148500	0.0	2844200	0	2844200	110431800
23	1500	6750000	321400	7600	148500	0.0	2789800	0	2789800	113221600
24	1500	6750000	321400	7600	148500	0.0	2735300	0	2735300	115956900
25	1500	6750000	321400	7600	148500	0.0	2680800	0	2680800	118637700
26	1500	6750000	321400	7600	148500	0.0	2626300	0	2626300	121264000
27	1500	6750000	321400	7600	148500	0.0	2571800	0	2571800	123835800
28	1500	6750000	321400	7600	148500	0.0	2517300	0	2517300	126353100
29	1500	6750000	321400	7600	148500	0.0	2462800	0	2462800	128815900
30	1500	6750000	321400	7600	148500	0.0	2408300	0	2408300	131224200
TOT	127500	573750000	27321000	648000	12622500		131224200	0	131224200	

	TOTAL OP. COST	TOTAL NET SALES REVENUE	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER
LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST			
DOLLARS PER TON OF COAL BURNED	4.80	0.0	4.80
MILLS PER KILOWATT-HOUR	2.06	0.0	2.06
CENTS PER MILLION BTU HEAT INPUT	22.87	0.0	22.87
DOLLARS PER TON OF SULFUR REMOVED	202.51	0.0	202.51
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS	45381700	0	45381700
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT			
DOLLARS PER TON OF COAL BURNED	4.26	0.0	4.26
MILLS PER KILOWATT-HOUR	1.83	0.0	1.83
CENTS PER MILLION BTU HEAT INPUT	20.29	0.0	20.29
DOLLARS PER TON OF SULFUR REMOVED	179.59	0.0	179.59

TABLE B-9

LIME/LIMESTONE SLUDGE DISPOSAL-IUCS PROCESS, 1500 MW NEW UNIT, 3.5% S, 16% ASH IN COAL, REGULATED CO. ECONOMICS.

FIXED INVESTMENT: $ 20105000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	7000	94500000	4500000	106800	2075500	0.0	12289300	0	12289300	12289300
2	7000	94500000	4500000	106800	2075500	0.0	12192200	0	12192200	24481500
3	7000	94500000	4500000	106800	2075500	0.0	12095100	0	12095100	36576600
4	7000	94500000	4500000	106800	2075500	0.0	11998000	0	11998000	48574600
5	7000	94500000	4500000	106800	2075500	0.0	11900900	0	11900900	60475500
6	7000	94500000	4500000	106800	2075500	0.0	11803800	0	11803800	72279300
7	7000	94500000	4500000	106800	2075500	0.0	11706700	0	11706700	83986000
8	7000	94500000	4500000	106800	2075500	0.0	11609600	0	11609600	95595600
9	7000	94500000	4500000	106800	2075500	0.0	11512500	0	11512500	107108100
10	7000	94500000	4500000	106800	2075500	0.0	11415600	0	11415600	118523500
11	5000	67500000	3214300	76300	1482500	0.0	9681000	0	9681000	128204500
12	5000	67500000	3214300	76300	1482500	0.0	9583900	0	9583900	137788400
13	5000	67500000	3214300	76300	1482500	0.0	9486800	0	9486800	147275200
14	5000	67500000	3214300	76300	1482500	0.0	9389700	0	9389700	156664900
15	5000	67500000	3214300	76300	1482500	0.0	9292600	0	9292600	165957500
16	3500	47250000	2250000	53400	1037800	0.0	7888400	0	7888400	173845900
17	3500	47250000	2250000	53400	1037800	0.0	7791300	0	7791300	181637200
18	3500	47250000	2250000	53400	1037800	0.0	7694200	0	7694200	189331400
19	3500	47250000	2250000	53400	1037800	0.0	7597100	0	7597100	196928500
20	3500	47250000	2250000	53400	1037800	0.0	7500000	0	7500000	204428500
21	1500	20250000	964300	22900	444800	0.0	5443900	0	5443900	209872400
22	1500	20250000	964300	22900	444800	0.0	5346800	0	5346800	215219200
23	1500	20250000	964300	22900	444800	0.0	5249700	0	5249700	220468900
24	1500	20250000	964300	22900	444800	0.0	5152600	0	5152600	225621500
25	1500	20250000	964300	22900	444800	0.0	5055500	0	5055500	230677000
26	1500	20250000	964300	22900	444800	0.0	4958400	0	4958400	235635400
27	1500	20250000	964300	22900	444800	0.0	4861300	0	4861300	240496700
28	1500	20250000	964300	22900	444800	0.0	4764200	0	4764200	245260900
29	1500	20250000	964300	22900	444800	0.0	4667100	0	4667100	249928000
30	1500	20250000	964300	22900	444800	0.0	4570000	0	4570000	254498000
TOT	127500	1721250000	81964500	1945500	37804500		254498000	0	254498000	
LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST										
DOLLARS PER TON OF COAL BURNED							3.10	0.0	3.10	
MILLS PER KILOWATT-HOUR							1.33	0.0	1.33	
CENTS PER MILLION BTU HEAT INPUT							14.79	0.0	14.79	
DOLLARS PER TON OF SULFUR REMOVED							130.81	0.0	130.81	
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS							88798600	0	88798600	
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT										
DOLLARS PER TON OF COAL BURNED							2.78	0.0	2.78	
MILLS PER KILOWATT-HOUR							1.19	0.0	1.19	
CENTS PER MILLION BTU HEAT INPUT							13.24	0.0	13.24	
DOLLARS PER TON OF SULFUR REMOVED							117.10	0.0	117.10	

TABLE B-10

LIME/LIMESTONE SLUDGE DISPOSAL-CHEMFIX PROCESS, 200 MW NEW UNIT, 3.5% S, 16% ASH IN COAL, REGULATED CO. ECONOMICS.

FIXED INVESTMENT: $ 9249000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	7000	12880000	613300	14600	290500	0.0	5360200	0	5360200	5360200
2	7000	12880000	613300	14600	290500	0.0	5311500	0	5311500	10671700
3	7000	12880000	613300	14600	290500	0.0	5262700	0	5262700	15934400
4	7000	12880000	613300	14600	290500	0.0	5214000	0	5214000	21148400
5	7000	12880000	613300	14600	290500	0.0	5165200	0	5165200	26313600
6	7000	12880000	613300	14600	290500	0.0	5116500	0	5116500	31430100
7	7000	12880000	613300	14600	290500	0.0	5067800	0	5067800	36497900
8	7000	12880000	613300	14600	290500	0.0	5019000	0	5019000	41516900
9	7000	12880000	613300	14600	290500	0.0	4970300	0	4970300	46487200
10	7000	12880000	613300	14600	290500	0.0	4921500	0	4921500	51408700
11	5000	9200000	438100	10400	207500	0.0	4241600	0	4241600	55650300
12	5000	9200000	438100	10400	207500	0.0	4192800	0	4192800	59843100
13	5000	9200000	438100	10400	207500	0.0	4144100	0	4144100	63987200
14	5000	9200000	438100	10400	207500	0.0	4095300	0	4095300	68082500
15	5000	9200000	438100	10400	207500	0.0	4046600	0	4046600	72129100
16	3500	6440000	306700	7300	145300	0.0	3482600	0	3482600	75611700
17	3500	6440000	306700	7300	145300	0.0	3433800	0	3433800	79045500
18	3500	6440000	306700	7300	145300	0.0	3385100	0	3385100	82430600
19	3500	6440000	306700	7300	145300	0.0	3336300	0	3336300	85766900
20	3500	6440000	306700	7300	145300	0.0	3287600	0	3287600	89054500
21	1500	2760000	131400	3100	62300	0.0	2438000	0	2438000	91492500
22	1500	2760000	131400	3100	62300	0.0	2389300	0	2389300	93881800
23	1500	2760000	131400	3100	62300	0.0	2340500	0	2340500	96222300
24	1500	2760000	131400	3100	62300	0.0	2291800	0	2291800	98514100
25	1500	2760000	131400	3100	62300	0.0	2243100	0	2243100	100757200
26	1500	2760000	131400	3100	62300	0.0	2194300	0	2194300	102951500
27	1500	2760000	131400	3100	62300	0.0	2145600	0	2145600	105097100
28	1500	2760000	131400	3100	62300	0.0	2096800	0	2096800	107193900
29	1500	2760000	131400	3100	62300	0.0	2048100	0	2048100	109242000
30	1500	2760000	131400	3100	62300	0.0	1999300	0	1999300	111241300
TOT	127500	234600000	11171000	265500	5292000		111241300	0	111241300	
LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST										
DOLLARS PER TON OF COAL BURNED							9.96	0.0	9.96	
MILLS PER KILOWATT-HOUR							4.36	0.0	4.36	
CENTS PER MILLION BTU HEAT INPUT							47.42	0.0	47.42	
DOLLARS PER TON OF SULFUR REMOVED							418.99	0.0	418.99	
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS							38655100	0	38655100	
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT										
DOLLARS PER TON OF COAL BURNED							8.88	0.0	8.88	
MILLS PER KILOWATT-HOUR							3.89	0.0	3.89	
CENTS PER MILLION BTU HEAT INPUT							42.27	0.0	42.27	
DOLLARS PER TON OF SULFUR REMOVED							373.12	0.0	373.12	

TABLE B-11

LIME/LIMESTONE SLUDGE DISPOSAL - CHEMFIX PROCESS, 500 MW NEW UNIT , 3.5% S, 16% ASH IN COAL, REGULATED CO, ECONOMICS

FIXED INVESTMENT: $ 13531000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	7000	31500000	1500000	35600	710500	0.0	8223700	0	8223700	8223700
2	7000	31500000	1500000	35600	710500	0.0	8154600	0	8154600	16378300
3	7000	31500000	1500000	35600	710500	0.0	8085500	0	8085500	24463800
4	7000	31500000	1500000	35600	710500	0.0	8016400	0	8016400	32480200
5	7000	31500000	1500000	35600	710500	0.0	7947300	0	7947300	40427500
6	7000	31500000	1500000	35600	710500	0.0	7878200	0	7878200	48305700
7	7000	31500000	1500000	35600	710500	0.0	7809100	0	7809100	56114800
8	7000	31500000	1500000	35600	710500	0.0	7740000	0	7740000	63854800
9	7000	31500000	1500000	35600	710500	0.0	7670900	0	7670900	71525700
10	7000	31500000	1500000	35600	710500	0.0	7601700	0	7601700	79127400
11	5000	22500000	1071400	25400	507500	0.0	6416100	0	6416100	85543500
12	5000	22500000	1071400	25400	507500	0.0	6347000	0	6347000	91890500
13	5000	22500000	1071400	25400	507500	0.0	6277900	0	6277900	98168400
14	5000	22500000	1071400	25400	507500	0.0	6208800	0	6208800	104377200
15	5000	22500000	1071400	25400	507500	0.0	6139700	0	6139700	110516900
16	3500	15750000	750000	17800	355300	0.0	5185400	0	5185400	115702300
17	3500	15750000	750000	17800	355300	0.0	5116300	0	5116300	120818600
18	3500	15750000	750000	17800	355300	0.0	5047200	0	5047200	125865800
19	3500	15750000	750000	17800	355300	0.0	4978100	0	4978100	130843900
20	3500	15750000	750000	17800	355300	0.0	4908900	0	4908900	135752800
21	1500	6750000	321400	7600	152300	0.0	3529900	0	3529900	139282700
22	1500	6750000	321400	7600	152300	0.0	3460800	0	3460800	142743500
23	1500	6750000	321400	7600	152300	0.0	3391700	0	3391700	146135200
24	1500	6750000	321400	7600	152300	0.0	3322600	0	3322600	149457800
25	1500	6750000	321400	7600	152300	0.0	3253500	0	3253500	152711300
26	1500	6750000	321400	7600	152300	0.0	3184400	0	3184400	155895700
27	1500	6750000	321400	7600	152300	0.0	3115300	0	3115300	159011000
28	1500	6750000	321400	7600	152300	0.0	3046200	0	3046200	162057200
29	1500	6750000	321400	7600	152300	0.0	2977100	0	2977100	165034300
30	1500	6750000	321400	7600	152300	0.0	2908000	0	2908000	167942300
TOT	127500	573750000	27321000	648000	12942000		167942300	0	167942300	
LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST										
DOLLARS PER TON OF COAL BURNED							6.15	0.0	6.15	
MILLS PER KILOWATT-HOUR							2.63	0.0	2.63	
CENTS PER MILLION BTU HEAT INPUT							29.27	0.0	29.27	
DOLLARS PER TON OF SULFUR REMOVED							259.17	0.0	259.17	
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS							59099300	0	59099300	
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT										
DOLLARS PER TON OF COAL BURNED							5.55	0.0	5.55	
MILLS PER KILOWATT-HOUR							2.38	0.0	2.38	
CENTS PER MILLION BTU HEAT INPUT							26.43	0.0	26.43	
DOLLARS PER TON OF SULFUR REMOVED							233.87	0.0	233.87	

TABLE B-12

LIME/LIMESTONE SLUDGE DISPOSAL-CHEMFIX PROCESS, 1500 MW NEW UNIT, 3.5% S, 16% ASH IN COAL, REGULATED CO. ECONOMICS.

FIXED INVESTMENT: $ 24104000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	7000	94500000	4500000	106800	2131500	0.0	16618100	0	16618100	16618100
2	7000	94500000	4500000	106800	2131500	0.0	16502200	0	16502200	33120300
3	7000	94500000	4500000	106800	2131500	0.0	16386400	0	16386400	49506700
4	7000	94500000	4500000	106800	2131500	0.0	16270600	0	16270600	65777300
5	7000	94500000	4500000	106800	2131500	0.0	16154700	0	16154700	81932000
6	7000	94500000	4500000	106800	2131500	0.0	16038900	0	16038900	97970900
7	7000	94500000	4500000	106800	2131500	0.0	15923000	0	15923000	113893900
8	7000	94500000	4500000	106800	2131500	0.0	15807200	0	15807200	129701100
9	7000	94500000	4500000	106800	2131500	0.0	15691400	0	15691400	145392500
10	7000	94500000	4500000	106800	2131500	0.0	15575500	0	15575500	160968000
11	5000	67500000	3214300	76300	1522500	0.0	12755100	0	12755100	173723100
12	5000	67500000	3214300	76300	1522500	0.0	12639200	0	12639200	186362300
13	5000	67500000	3214300	76300	1522500	0.0	12523400	0	12523400	198885700
14	5000	67500000	3214300	76300	1522500	0.0	12407500	0	12407500	211293200
15	5000	67500000	3214300	76300	1522500	0.0	12291700	0	12291700	223584900
16	3500	47250000	2250000	53400	1065800	0.0	10086400	0	10086400	233671300
17	3500	47250000	2250000	53400	1065800	0.0	9970500	0	9970500	243641800
18	3500	47250000	2250000	53400	1065800	0.0	9854700	0	9854700	253496500
19	3500	47250000	2250000	53400	1065800	0.0	9738800	0	9738800	263235300
20	3500	47250000	2250000	53400	1065800	0.0	9623000	0	9623000	272858300
21	1500	20250000	964300	22900	456800	0.0	6554500	0	6554500	279412800
22	1500	20250000	964300	22900	456800	0.0	6438700	0	6438700	285851500
23	1500	20250000	964300	22900	456800	0.0	6322900	0	6322900	292174400
24	1500	20250000	964300	22900	456800	0.0	6207000	0	6207000	298381400
25	1500	20250000	964300	22900	456800	0.0	6091200	0	6091200	304472600
26	1500	20250000	964300	22900	456800	0.0	5975300	0	5975300	310447900
27	1500	20250000	964300	22900	456800	0.0	5859500	0	5859500	316307400
28	1500	20250000	964300	22900	456800	0.0	5743700	0	5743700	322051100
29	1500	20250000	964300	22900	456800	0.0	5627800	0	5627800	327678900
30	1500	20250000	964300	22900	456800	0.0	5512000	0	5512000	333190900
TOT	127500	1721250000	81964500	1945500	38824500		333190900	0	333190900	
LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST										
DOLLARS PER TON OF COAL BURNED							4.07	0.0	4.07	
MILLS PER KILOWATT-HOUR							1.74	0.0	1.74	
CENTS PER MILLION BTU HEAT INPUT							19.36	0.0	19.36	
DOLLARS PER TON OF SULFUR REMOVED							171.26	0.0	171.26	
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS							119154500	0	119154500	
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT										
DOLLARS PER TON OF COAL BURNED							3.73	0.0	3.73	
MILLS PER KILOWATT-HOUR							1.60	0.0	1.60	
CENTS PER MILLION BTU HEAT INPUT							17.76	0.0	17.76	
DOLLARS PER TON OF SULFUR REMOVED							157.13	0.0	157.13	

APPENDIX C

CONSTANT ON-STREAM TIME - LIFETIME REVENUE REQUIREMENTS

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TABLE C-1

LIME/LIMESTONE SLUDGE DISPOSAL - UNTREATED, 200 MW NEW UNIT , 3.5% S, 7000 HRS CONSTANT ONSTEAM, REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 12882000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	7000	12880000	613300	14600	332500	0.0	3662300	0	3662300	3662300
2	7000	12880000	613300	14600	332500	0.0	3595000	0	3595000	7257300
3	7000	12880000	613300	14600	332500	0.0	3527700	0	3527700	10785000
4	7000	12880000	613300	14600	332500	0.0	3460300	0	3460300	14245300
5	7000	12880000	613300	14600	332500	0.0	3393000	0	3393000	17638300
6	7000	12880000	613300	14600	332500	0.0	3325700	0	3325700	20964000
7	7000	12880000	613300	14600	332500	0.0	3258400	0	3258400	24222400
8	7000	12880000	613300	14600	332500	0.0	3191100	0	3191100	27413500
9	7000	12880000	613300	14600	332500	0.0	3123700	0	3123700	30537200
10	7000	12880000	613300	14600	332500	0.0	3056400	0	3056400	33593600
11	7000	12880000	613300	14600	332500	0.0	2989100	0	2989100	36582700
12	7000	12880000	613300	14600	332500	0.0	2921800	0	2921800	39504500
13	7000	12880000	613300	14600	332500	0.0	2854500	0	2854500	42359000
14	7000	12880000	613300	14600	332500	0.0	2787100	0	2787100	45146100
15	7000	12880000	613300	14600	332500	0.0	2719800	0	2719800	47865900
16	7000	12880000	613300	14600	332500	0.0	2652500	0	2652500	50518400
17	7000	12880000	613300	14600	332500	0.0	2585200	0	2585200	53103600
18	7000	12880000	613300	14600	332500	0.0	2517900	0	2517900	55621500
19	7000	12880000	613300	14600	332500	0.0	2450500	0	2450500	58072000
20	7000	12880000	613300	14600	332500	0.0	2383200	0	2383200	60455200
21	7000	12880000	613300	14600	332500	0.0	2315900	0	2315900	62771100
22	7000	12880000	613300	14600	332500	0.0	2248600	0	2248600	65019700
23	7000	12880000	613300	14600	332500	0.0	2181200	0	2181200	67200900
24	7000	12880000	613300	14600	332500	0.0	2113900	0	2113900	69314800
25	7000	12880000	613300	14600	332500	0.0	2046600	0	2046600	71361400
26	7000	12880000	613300	14600	332500	0.0	1979300	0	1979300	73340700
27	7000	12880000	613300	14600	332500	0.0	1912000	0	1912000	75252700
28	7000	12880000	613300	14600	332500	0.0	1844600	0	1844600	77097300
29	7000	12880000	613300	14600	332500	0.0	1777300	0	1777300	78874600
30	7000	12880000	613300	14600	332500	0.0	1710000	0	1710000	80584600
TOT	210000	386400000	18399000	438000	9975000		80584600	0	80584600	

LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST			
DOLLARS PER TON OF COAL BURNED	4.38	0.0	4.38
MILLS PER KILOWATT-HOUR	1.92	0.0	1.92
CENTS PER MILLION BTU HEAT INPUT	20.86	0.0	20.86
DOLLARS PER TON OF SULFUR REMOVED	183.98	0.0	183.98
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS	26228200	0	26228200
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT			
DOLLARS PER TON OF COAL BURNED	5.15	0.0	5.15
MILLS PER KILOWATT-HOUR	2.26	0.0	2.26
CENTS PER MILLION BTU HEAT INPUT	24.53	0.0	24.53
DOLLARS PER TON OF SULFUR REMOVED	216.40	0.0	216.40

TABLE C-2

LIME/LIMESTONE SLUDGE DISPOSAL - UNTREATED, 200 MW NEW UNIT, 3.5% S, 5000 HRS CONSTANT ONSTEAM, REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 10682000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	5000	9200000	438100	10400	237500	0.0	3101900	0	3101900	3101900
2	5000	9200000	438100	10400	237500	0.0	3045800	0	3045800	6147700
3	5000	9200000	438100	10400	237500	0.0	2989600	0	2989600	9137300
4	5000	9200000	438100	10400	237500	0.0	2933500	0	2933500	12070800
5	5000	9200000	438100	10400	237500	0.0	2877300	0	2877300	14948100
6	5000	9200000	438100	10400	237500	0.0	2821200	0	2821200	17769300
7	5000	9200000	438100	10400	237500	0.0	2765100	0	2765100	20534400
8	5000	9200000	438100	10400	237500	0.0	2708900	0	2708900	23243300
9	5000	9200000	438100	10400	237500	0.0	2652800	0	2652800	25896100
10	5000	9200000	438100	10400	237500	0.0	2596600	0	2596600	28492700
11	5000	9200000	438100	10400	237500	0.0	2540500	0	2540500	31033200
12	5000	9200000	438100	10400	237500	0.0	2484400	0	2484400	33517600
13	5000	9200000	438100	10400	237500	0.0	2428200	0	2428200	35945800
14	5000	9200000	438100	10400	237500	0.0	2372100	0	2372100	38317900
15	5000	9200000	438100	10400	237500	0.0	2315900	0	2315900	40633800
16	5000	9200000	438100	10400	237500	0.0	2259800	0	2259800	42893600
17	5000	9200000	438100	10400	237500	0.0	2203700	0	2203700	45097300
18	5000	9200000	438100	10400	237500	0.0	2147500	0	2147500	47244800
19	5000	9200000	438100	10400	237500	0.0	2091400	0	2091400	49336200
20	5000	9200000	438100	10400	237500	0.0	2035200	0	2035200	51371400
21	5000	9200000	438100	10400	237500	0.0	1979100	0	1979100	53350500
22	5000	9200000	438100	10400	237500	0.0	1922900	0	1922900	55273400
23	5000	9200000	438100	10400	237500	0.0	1866800	0	1866800	57140200
24	5000	9200000	438100	10400	237500	0.0	1810700	0	1810700	58950900
25	5000	9200000	438100	10400	237500	0.0	1754500	0	1754500	60705400
26	5000	9200000	438100	10400	237500	0.0	1698400	0	1698400	62403800
27	5000	9200000	438100	10400	237500	0.0	1642200	0	1642200	64046000
28	5000	9200000	438100	10400	237500	0.0	1586100	0	1586100	65632100
29	5000	9200000	438100	10400	237500	0.0	1530000	0	1530000	67162100
30	5000	9200000	438100	10400	237500	0.0	1473800	0	1473800	68635900
TOT	150000	276000000	13143000	312000	7125000		68635900	0	68635900	

LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST			
DOLLARS PER TON OF COAL BURNED	5.22	0.0	5.22
MILLS PER KILOWATT-HOUR	2.29	0.0	2.29
CENTS PER MILLION BTU HEAT INPUT	24.87	0.0	24.87
DOLLARS PER TON OF SULFUR REMOVED	219.99	0.0	219.99
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS	22269300	0	22269300
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT			
DOLLARS PER TON OF COAL BURNED	6.12	0.0	6.12
MILLS PER KILOWATT-HOUR	2.68	0.0	2.68
CENTS PER MILLION BTU HEAT INPUT	29.16	0.0	29.16
DOLLARS PER TON OF SULFUR REMOVED	258.05	0.0	258.05

TABLE C-3

LIME/LIMESTONE SLUDGE DISPOSAL - UNTREATED, 500 MW NEW UNIT , 3.5% S, 7000 HRS CONSTANT ONSTEAM, REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 23272000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	7000	31500000	1500000	35600	812000	0.0	6345200	0	6345200	6345200
2	7000	31500000	1500000	35600	812000	0.0	6224600	0	6224600	12569800
3	7000	31500000	1500000	35600	812000	0.0	6104000	0	6104000	18673800
4	7000	31500000	1500000	35600	812000	0.0	5983400	0	5983400	24657200
5	7000	31500000	1500000	35600	812000	0.0	5862800	0	5862800	30520000
6	7000	31500000	1500000	35600	812000	0.0	5742200	0	5742200	36262200
7	7000	31500000	1500000	35600	812000	0.0	5621600	0	5621600	41883800
8	7000	31500000	1500000	35600	812000	0.0	5501100	0	5501100	47384900
9	7000	31500000	1500000	35600	812000	0.0	5380500	0	5380500	52765400
10	7000	31500000	1500000	35600	812000	0.0	5259900	0	5259900	58025300
11	7000	31500000	1500000	35600	812000	0.0	5139300	0	5139300	63164600
12	7000	31500000	1500000	35600	812000	0.0	5018700	0	5018700	68183300
13	7000	31500000	1500000	35600	812000	0.0	4898100	0	4898100	73081400
14	7000	31500000	1500000	35600	812000	0.0	4777500	0	4777500	77858900
15	7000	31500000	1500000	35600	812000	0.0	4656900	0	4656900	82515800
16	7000	31500000	1500000	35600	812000	0.0	4536300	0	4536300	87052100
17	7000	31500000	1500000	35600	812000	0.0	4415800	0	4415800	91467900
18	7000	31500000	1500000	35600	812000	0.0	4295200	0	4295200	95763100
19	7000	31500000	1500000	35600	812000	0.0	4174600	0	4174600	99937700
20	7000	31500000	1500000	35600	812000	0.0	4054000	0	4054000	103991700
21	7000	31500000	1500000	35600	812000	0.0	3933400	0	3933400	107925100
22	7000	31500000	1500000	35600	812000	0.0	3812800	0	3812800	111737900
23	7000	31500000	1500000	35600	812000	0.0	3692200	0	3692200	115430100
24	7000	31500000	1500000	35600	812000	0.0	3571600	0	3571600	119001700
25	7000	31500000	1500000	35600	812000	0.0	3451000	0	3451000	122452700
26	7000	31500000	1500000	35600	812000	0.0	3330500	0	3330500	125783200
27	7000	31500000	1500000	35600	812000	0.0	3209900	0	3209900	128993100
28	7000	31500000	1500000	35600	812000	0.0	3089300	0	3089300	132082400
29	7000	31500000	1500000	35600	812000	0.0	2968700	0	2968700	135051100
30	7000	31500000	1500000	35600	812000	0.0	2848100	0	2848100	137899200
TOT	210000	945000000	45000000	1068000	24360000		137899200	0	137899200	

LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST			
DOLLARS PER TON OF COAL BURNED	3.06	0.0	3.06
MILLS PER KILOWATT-HOUR	1.31	0.0	1.31
CENTS PER MILLION BTU HEAT INPUT	14.59	0.0	14.59
DOLLARS PER TON OF SULFUR REMOVED	129.12	0.0	129.12
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS	45197300	0	45197300
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT			
DOLLARS PER TON OF COAL BURNED	3.63	0.0	3.63
MILLS PER KILOWATT-HOUR	1.56	0.0	1.56
CENTS PER MILLION BTU HEAT INPUT	17.29	0.0	17.29
DOLLARS PER TON OF SULFUR REMOVED	152.95	0.0	152.95

TABLE C-4

LIME/LIMESTONE SLUDGE DISPOSAL - UNTREATED, 500 MW NEW UNIT, 3.5% S, 5000 HRS CONSTANT ONSTEAM, REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 18937000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	5000	22500000	1071400	25400	580000	0.0	5229600	0	5229600	5229600
2	5000	22500000	1071400	25400	580000	0.0	5130900	0	5130900	10360500
3	5000	22500000	1071400	25400	580000	0.0	5032300	0	5032300	15392800
4	5000	22500000	1071400	25400	580000	0.0	4933600	0	4933600	20326400
5	5000	22500000	1071400	25400	580000	0.0	4835000	0	4835000	25161600
6	5000	22500000	1071400	25400	580000	0.0	4736400	0	4736400	29897800
7	5000	22500000	1071400	25400	580000	0.0	4637700	0	4637700	34535500
8	5000	22500000	1071400	25400	580000	0.0	4539100	0	4539100	39074600
9	5000	22500000	1071400	25400	580000	0.0	4440400	0	4440400	43515000
10	5000	22500000	1071400	25400	580000	0.0	4341800	0	4341800	47856800
11	5000	22500000	1071400	25400	580000	0.0	4243100	0	4243100	52099900
12	5000	22500000	1071400	25400	580000	0.0	4144500	0	4144500	56244400
13	5000	22500000	1071400	25400	580000	0.0	4045900	0	4045900	60290300
14	5000	22500000	1071400	25400	580000	0.0	3947200	0	3947200	64237500
15	5000	22500000	1071400	25400	580000	0.0	3848600	0	3848600	68086100
16	5000	22500000	1071400	25400	580000	0.0	3749900	0	3749900	71836000
17	5000	22500000	1071400	25400	580000	0.0	3651300	0	3651300	75487300
18	5000	22500000	1071400	25400	580000	0.0	3552700	0	3552700	79040000
19	5000	22500000	1071400	25400	580000	0.0	3454000	0	3454000	82494000
20	5000	22500000	1071400	25400	580000	0.0	3355600	0	3355600	85849600
21	5000	22500000	1071400	25400	580000	0.0	3256700	0	3256700	89106100
22	5000	22500000	1071400	25400	580000	0.0	3158100	0	3158100	92264200
23	5000	22500000	1071400	25400	580000	0.0	3059400	0	3059400	95323600
24	5000	22500000	1071400	25400	580000	0.0	2960800	0	2960800	98284400
25	5000	22500000	1071400	25400	580000	0.0	2862200	0	2862200	101146600
26	5000	22500000	1071400	25400	580000	0.0	2763500	0	2763500	103910100
27	5000	22500000	1071400	25400	580000	0.0	2664900	0	2664900	106575000
28	5000	22500000	1071400	25400	580000	0.0	2566200	0	2566200	109141200
29	5000	22500000	1071400	25400	580000	0.0	2467600	0	2467600	111608800
30	5000	22500000	1071400	25400	580000	0.0	2368900	0	2368900	113977700
TOT	150000	675000000	32142000	762000	17400000		113977700	0	113977700	

LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST			
DOLLARS PER TON OF COAL BURNED	3.55	0.0	3.55
MILLS PER KILOWATT-HOUR	1.52	0.0	1.52
CENTS PER MILLION BTU HEAT INPUT	16.89	0.0	16.89
DOLLARS PER TON OF SULFUR REMOVED	149.58	0.0	149.58
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS	37296900	0	37296900
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT			
DOLLARS PER TON OF COAL BURNED	4.19	0.0	4.19
MILLS PER KILOWATT-HOUR	1.80	0.0	1.80
CENTS PER MILLION BTU HEAT INPUT	19.97	0.0	19.97
DOLLARS PER TON OF SULFUR REMOVED	176.93	0.0	176.93

TABLE C-5

LIME/LIMESTONE SLUDGE DISPOSAL - UNTREATED, 1500 MW NEW UNIT , 3.5% S, 7000 HRS CONSTANT ONSTEAM, REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 50462000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	7000	94500000	4500000	106800	2432500	0.0	13549000	0	13549000	13549000
2	7000	94500000	4500000	106800	2432500	0.0	13289700	0	13289700	26838700
3	7000	94500000	4500000	106800	2432500	0.0	13030400	0	13030400	39869100
4	7000	94500000	4500000	106800	2432500	0.0	12771100	0	12771100	52640200
5	7000	94500000	4500000	106800	2432500	0.0	12511800	0	12511800	65152000
6	7000	94500000	4500000	106800	2432500	0.0	12252500	0	12252500	77404500
7	7000	94500000	4500000	106800	2432500	0.0	11993200	0	11993200	89397700
8	7000	94500000	4500000	106800	2432500	0.0	11733900	0	11733900	101131600
9	7000	94500000	4500000	106800	2432500	0.0	11474600	0	11474600	112606200
10	7000	94500000	4500000	106800	2432500	0.0	11215400	0	11215400	123821600
11	7000	94500000	4500000	106800	2432500	0.0	10956100	0	10956100	134777700
12	7000	94500000	4500000	106800	2432500	0.0	10696800	0	10696800	145474500
13	7000	94500000	4500000	106800	2432500	0.0	10437500	0	10437500	155912000
14	7000	94500000	4500000	106800	2432500	0.0	10178200	0	10178200	166090200
15	7000	94500000	4500000	106800	2432500	0.0	9918900	0	9918900	176009100
16	7000	94500000	4500000	106800	2432500	0.0	9659600	0	9659600	185668700
17	7000	94500000	4500000	106800	2432500	0.0	9400300	0	9400300	195069000
18	7000	94500000	4500000	106800	2432500	0.0	9141000	0	9141000	204210000
19	7000	94500000	4500000	106800	2432500	0.0	8881700	0	8881700	213091700
20	7000	94500000	4500000	106800	2432500	0.0	8622500	0	8622500	221714200
21	7000	94500000	4500000	106800	2432500	0.0	8363200	0	8363200	230077400
22	7000	94500000	4500000	106800	2432500	0.0	8103900	0	8103900	238181300
23	7000	94500000	4500000	106800	2432500	0.0	7844600	0	7844600	246025900
24	7000	94500000	4500000	106800	2432500	0.0	7585300	0	7585300	253611200
25	7000	94500000	4500000	106800	2432500	0.0	7326000	0	7326000	260937200
26	7000	94500000	4500000	106800	2432500	0.0	7066700	0	7066700	268003900
27	7000	94500000	4500000	106800	2432500	0.0	6807400	0	6807400	274811300
28	7000	94500000	4500000	106800	2432500	0.0	6548100	0	6548100	281359400
29	7000	94500000	4500000	106800	2432500	0.0	6288800	0	6288800	287648200
30	7000	94500000	4500000	106800	2432500	0.0	6029600	0	6029600	293677800
TOT	210000	2835000000	135000000	3204000	72975000		293677800	0	293677800	

LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST			
DOLLARS PER TON OF COAL BURNED	2.18	0.0	2.18
MILLS PER KILOWATT-HOUR	0.93	0.0	0.93
CENTS PER MILLION BTU HEAT INPUT	10.36	0.0	10.36
DOLLARS PER TON OF SULFUR REMOVED	91.66	0.0	91.66
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS	96399600	0	96399600
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT			
DOLLARS PER TON OF COAL BURNED	2.58	0.0	2.58
MILLS PER KILOWATT-HOUR	1.11	0.0	1.11
CENTS PER MILLION BTU HEAT INPUT	12.29	0.0	12.29
DOLLARS PER TON OF SULFUR REMOVED	108.74	0.0	108.74

TABLE C-6

LIME/LIMESTONE SLUDGE DISPOSAL - UNTREATED, 1500 MW UNIT, 3.5% S, 5000 HRS CONSTANT UNSTEAM, REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 40438000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	5000	67500000	3214300	76300	1737500	0.0	10961000	0	10961000	10961000
2	5000	67500000	3214300	76300	1737500	0.0	10752400	0	10752400	21713400
3	5000	67500000	3214300	76300	1737500	0.0	10543800	0	10543800	32257200
4	5000	67500000	3214300	76300	1737500	0.0	10335100	0	10335100	42592300
5	5000	67500000	3214300	76300	1737500	0.0	10126500	0	10126500	52718800
6	5000	67500000	3214300	76300	1737500	0.0	9917900	0	9917900	62636700
7	5000	67500000	3214300	76300	1737500	0.0	9709200	0	9709200	72345900
8	5000	67500000	3214300	76300	1737500	0.0	9500600	0	9500600	81846500
9	5000	67500000	3214300	76300	1737500	0.0	9291900	0	9291900	91138400
10	5000	67500000	3214300	76300	1737500	0.0	9083300	0	9083300	100221700
11	5000	67500000	3214300	76300	1737500	0.0	8874700	0	8874700	109096400
12	5000	67500000	3214300	76300	1737500	0.0	8666000	0	8666000	117762400
13	5000	67500000	3214300	76300	1737500	0.0	8457400	0	8457400	126219800
14	5000	67500000	3214300	76300	1737500	0.0	8248800	0	8248800	134468600
15	5000	67500000	3214300	76300	1737500	0.0	8040100	0	8040100	142508700
16	5000	67500000	3214300	76300	1737500	0.0	7831500	0	7831500	150340200
17	5000	67500000	3214300	76300	1737500	0.0	7622900	0	7622900	157963100
18	5000	67500000	3214300	76300	1737500	0.0	7414200	0	7414200	165377300
19	5000	67500000	3214300	76300	1737500	0.0	7205600	0	7205600	172582900
20	5000	67500000	3214300	76300	1737500	0.0	6997000	0	6997000	179579900
21	5000	67500000	3214300	76300	1737500	0.0	6788300	0	6788300	186368200
22	5000	67500000	3214300	76300	1737500	0.0	6579700	0	6579700	192947900
23	5000	67500000	3214300	76300	1737500	0.0	6371000	0	6371000	199318900
24	5000	67500000	3214300	76300	1737500	0.0	6162400	0	6162400	205481300
25	5000	67500000	3214300	76300	1737500	0.0	5953800	0	5953800	211435100
26	5000	67500000	3214300	76300	1737500	0.0	5745100	0	5745100	217180200
27	5000	67500000	3214300	76300	1737500	0.0	5536500	0	5536500	222716700
28	5000	67500000	3214300	76300	1737500	0.0	5327900	0	5327900	228044600
29	5000	67500000	3214300	76300	1737500	0.0	5119200	0	5119200	233163800
30	5000	67500000	3214300	76300	1737500	0.0	4910600	0	4910600	238074400
TOT	150000	2025000000	96429000	2289000	52125000		238074400	0	238074400	
LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST										
DOLLARS PER TON OF COAL BURNED							2.47	0.0	2.47	
MILLS PER KILOWATT-HOUR							1.06	0.0	1.06	
CENTS PER MILLION BTU HEAT INPUT							11.76	0.0	11.76	
DOLLARS PER TON OF SULFUR REMOVED							104.01	0.0	104.01	
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS							78056500	0	78056500	
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT										
DOLLARS PER TON OF COAL BURNED							2.93	0.0	2.93	
MILLS PER KILOWATT-HOUR							1.25	0.0	1.25	
CENTS PER MILLION BTU HEAT INPUT							13.93	0.0	13.93	
DOLLARS PER TON OF SULFUR REMOVED							123.25	0.0	123.25	

TABLE C-7

LIME/LIMESTONE SLUDGE DISPOSAL - DRAVO PROCESS, 200 MW NEW UNIT, 3.5% S, 7000 CONSTANT ONSTEAM, REGULATED CO. ECONOMICS

FIXED INVESTMENT:, $ 16875000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	7000	12880000	613300	14600	35700	0.0	5615300	0	5615300	5615300
2	7000	12880000	613300	14600	35700	0.0	5525800	0	5525800	11141100
3	7000	12880000	613300	14600	35700	0.0	5436400	0	5436400	16577500
4	7000	12880000	613300	14600	35700	0.0	5346900	0	5346900	21924400
5	7000	12880000	613300	14600	35700	0.0	5257600	0	5257600	27181800
6	7000	12880000	613300	14600	35700	0.0	5167900	0	5167900	32349700
7	7000	12880000	613300	14600	35700	0.0	5078500	0	5078500	37428200
8	7000	12880000	613300	14600	35700	0.0	4989000	0	4989000	42417200
9	7000	12880000	613300	14600	35700	0.0	4899500	0	4899500	47316700
10	7000	12880000	613300	14600	35700	0.0	4810000	0	4810000	52126700
11	7000	12880000	613300	14600	35700	0.0	4720600	0	4720600	56847300
12	7000	12880000	613300	14600	35700	0.0	4631100	0	4631100	61478400
13	7000	12880000	613300	14600	35700	0.0	4541600	0	4541600	66020000
14	7000	12880000	613300	14600	35700	0.0	4452100	0	4452100	70472100
15	7000	12880000	613300	14600	35700	0.0	4362700	0	4362700	74834800
16	7000	12880000	613300	14600	35700	0.0	4273200	0	4273200	79108000
17	7000	12880000	613300	14600	35700	0.0	4183700	0	4183700	83291700
18	7000	12880000	613300	14600	35700	0.0	4094200	0	4094200	87385900
19	7000	12880000	613300	14600	35700	0.0	4004800	0	4004800	91390700
20	7000	12880000	613300	14600	35700	0.0	3915300	0	3915300	95306000
21	7000	12880000	613300	14600	35700	0.0	3825800	0	3825800	99131800
22	7000	12880000	613300	14600	35700	0.0	3736300	0	3736300	102868100
23	7000	12880000	613300	14600	35700	0.0	3646900	0	3646900	106515000
24	7000	12880000	613300	14600	35700	0.0	3557400	0	3557400	110072400
25	7000	12880000	613300	14600	35700	0.0	3467900	0	3467900	113540300
26	7000	12880000	613300	14600	35700	0.0	3378400	0	3378400	116918700
27	7000	12880000	613300	14600	35700	0.0	3289000	0	3289000	120207700
28	7000	12880000	613300	14600	35700	0.0	3199500	0	3199500	123407200
29	7000	12880000	613300	14600	35700	0.0	3110000	0	3110000	126517200
30	7000	12880000	613300	14600	35700	0.0	3020500	0	3020500	129537700
TOT	210000	386400000	18399000	438000	1071000		129537700	0	129537700	
LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST										
DOLLARS PER TON OF COAL BURNED							7.04	0.0	7.04	
MILLS PER KILOWATT-HOUR							3.08	0.0	3.08	
CENTS PER MILLION BTU HEAT INPUT							33.52	0.0	33.52	
DOLLARS PER TON OF SULFUR REMOVED							295.75	0.0	295.75	
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS							41066500	0	41066500	
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT										
DOLLARS PER TON OF COAL BURNED							8.07	0.0	8.07	
MILLS PER KILOWATT-HOUR							3.53	0.0	3.53	
CENTS PER MILLION BTU HEAT INPUT							38.41	0.0	38.41	
DOLLARS PER TON OF SULFUR REMOVED							338.83	0.0	338.83	

TABLE C-8

LIME/LIMESTONE SLUDGE DISPOSAL - DRAVO PROCESS, 200 MW NEW UNIT, 3.5% S, 5000 HRS CONSTANT ONSTEAM, REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 14759000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	5000	9200000	438100	10400	25500	0.0	4865200	0	4865200	4865200
2	5000	9200000	438100	10400	25500	0.0	4786400	0	4786400	9651600
3	5000	9200000	438100	10400	25500	0.0	4707500	0	4707500	14359100
4	5000	9200000	438100	10400	25500	0.0	4628700	0	4628700	18987800
5	5000	9200000	438100	10400	25500	0.0	4549800	0	4549800	23537600
6	5000	9200000	438100	10400	25500	0.0	4470900	0	4470900	28008500
7	5000	9200000	438100	10400	25500	0.0	4392100	0	4392100	32400600
8	5000	9200000	438100	10400	25500	0.0	4313200	0	4313200	36713800
9	5000	9200000	438100	10400	25500	0.0	4234400	0	4234400	40948200
10	5000	9200000	438100	10400	25500	0.0	4155500	0	4155500	45103700
11	5000	9200000	438100	10400	25500	0.0	4076600	0	4076600	49180300
12	5000	9200000	438100	10400	25500	0.0	3997800	0	3997800	53178100
13	5000	9200000	438100	10400	25500	0.0	3918900	0	3918900	57097000
14	5000	9200000	438100	10400	25500	0.0	3840000	0	3840000	60937000
15	5000	9200000	438100	10400	25500	0.0	3761200	0	3761200	64698200
16	5000	9200000	438100	10400	25500	0.0	3682300	0	3682300	68380500
17	5000	9200000	438100	10400	25500	0.0	3603500	0	3603500	71984000
18	5000	9200000	438100	10400	25500	0.0	3524600	0	3524600	75508600
19	5000	9200000	438100	10400	25500	0.0	3445700	0	3445700	78954300
20	5000	9200000	438100	10400	25500	0.0	3366900	0	3366900	82321200
21	5000	9200000	438100	10400	25500	0.0	3288000	0	3288000	85609200
22	5000	9200000	438100	10400	25500	0.0	3209100	0	3209100	88818300
23	5000	9200000	438100	10400	25500	0.0	3130300	0	3130300	91948600
24	5000	9200000	438100	10400	25500	0.0	3051400	0	3051400	95000000
25	5000	9200000	438100	10400	25500	0.0	2972600	0	2972600	97972600
26	5000	9200000	438100	10400	25500	0.0	2893700	0	2893700	100866300
27	5000	9200000	438100	10400	25500	0.0	2814800	0	2814800	103681100
28	5000	9200000	438100	10400	25500	0.0	2736000	0	2736000	106417100
29	5000	9200000	438100	10400	25500	0.0	2657100	0	2657100	109074200
30	5000	9200000	438100	10400	25500	0.0	2578300	0	2578300	111652500
TOT	150000	276000000	13143000	312000	765000		111652500	0	111652500	

LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST			
DOLLARS PER TON OF COAL BURNED	8.50	0.0	8.50
MILLS PER KILOWATT-HOUR	3.72	0.0	3.72
CENTS PER MILLION BTU HEAT INPUT	40.45	0.0	40.45
DOLLARS PER TON OF SULFUR REMOVED	357.86	0.0	357.86
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS	35498100	0	35498100
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT			
DOLLARS PER TON OF COAL BURNED	9.76	0.0	9.76
MILLS PER KILOWATT-HOUR	4.28	0.0	4.28
CENTS PER MILLION BTU HEAT INPUT	46.49	0.0	46.49
DOLLARS PER TON OF SULFUR REMOVED	411.33	0.0	411.33

TABLE C-9

LIME/LIMESTONE SLUDGE DISPOSAL - DRAVO PROCESS, 500 MW NEW UNIT, 3.5% S, 7000 CONSTANT ONSTEAM, REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 30293000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	7000	31500000	1500000	35600	875000	0.0	10405500	0	10405500	10405500
2	7000	31500000	1500000	35600	875000	0.0	10247300	0	10247300	20652800
3	7000	31500000	1500000	35600	875000	0.0	10089100	0	10089100	30741900
4	7000	31500000	1500000	35600	875000	0.0	9930900	0	9930900	40672800
5	7000	31500000	1500000	35600	875000	0.0	9772700	0	9772700	50445500
6	7000	31500000	1500000	35600	875000	0.0	9614600	0	9614600	60060100
7	7000	31500000	1500000	35600	875000	0.0	9456400	0	9456400	69516500
8	7000	31500000	1500000	35600	875000	0.0	9298200	0	9298200	78814700
9	7000	31500000	1500000	35600	875000	0.0	9140000	0	9140000	87954700
10	7000	31500000	1500000	35600	875000	0.0	8981800	0	8981800	96936500
11	7000	31500000	1500000	35600	875000	0.0	8823600	0	8823600	105760100
12	7000	31500000	1500000	35600	875000	0.0	8665400	0	8665400	114425500
13	7000	31500000	1500000	35600	875000	0.0	8507200	0	8507200	122932700
14	7000	31500000	1500000	35600	875000	0.0	8349000	0	8349000	131281700
15	7000	31500000	1500000	35600	875000	0.0	8190900	0	8190900	139472600
16	7000	31500000	1500000	35600	875000	0.0	8032700	0	8032700	147505300
17	7000	31500000	1500000	35600	875000	0.0	7874500	0	7874500	155379800
18	7000	31500000	1500000	35600	875000	0.0	7716300	0	7716300	163096100
19	7000	31500000	1500000	35600	875000	0.0	7558100	0	7558100	170654200
20	7000	31500000	1500000	35600	875000	0.0	7399900	0	7399900	178054100
21	7000	31500000	1500000	35600	875000	0.0	7241700	0	7241700	185295800
22	7000	31500000	1500000	35600	875000	0.0	7083500	0	7083500	192379300
23	7000	31500000	1500000	35600	875000	0.0	6925400	0	6925400	199304700
24	7000	31500000	1500000	35600	875000	0.0	6767200	0	6767200	206071900
25	7000	31500000	1500000	35600	875000	0.0	6609000	0	6609000	212680900
26	7000	31500000	1500000	35600	875000	0.0	6450800	0	6450800	219131700
27	7000	31500000	1500000	35600	875000	0.0	6292600	0	6292600	225424300
28	7000	31500000	1500000	35600	875000	0.0	6134400	0	6134400	231558700
29	7000	31500000	1500000	35600	875000	0.0	5976200	0	5976200	237534900
30	7000	31500000	1500000	35600	875000	0.0	5818000	0	5818000	243352900
TOT	210000	945000000	45000000	1068000	26250000		243352900	0	243352900	
LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST										
DOLLARS PER TON OF COAL BURNED							5.41	0.0	5.41	
MILLS PER KILOWATT-HOUR							2.32	0.0	2.32	
CENTS PER MILLION BTU HEAT INPUT							25.75	0.0	25.75	
DOLLARS PER TON OF SULFUR REMOVED							227.86	0.0	227.86	
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS							76570300	0	76570300	
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT										
DOLLARS PER TON OF COAL BURNED							6.15	0.0	6.15	
MILLS PER KILOWATT-HOUR							2.64	0.0	2.64	
CENTS PER MILLION BTU HEAT INPUT							29.29	0.0	29.29	
DOLLARS PER TON OF SULFUR REMOVED							259.12	0.0	259.12	

TABLE C-10

LIME/LIMESTONE SLUDGE DISPOSAL - DRAVO PROCESS, 500 MW NEW UNIT, 3.5% S, 5000 HRS CONSTANT ONSTEAM, REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 25771000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	5000	22500000	1071400	25400	625000	0.0	8702300	0	8702300	8702300
2	5000	22500000	1071400	25400	625000	0.0	8566600	0	8566600	17268900
3	5000	22500000	1071400	25400	625000	0.0	8430900	0	8430900	25699800
4	5000	22500000	1071400	25400	625000	0.0	8295200	0	8295200	33995000
5	5000	22500000	1071400	25400	625000	0.0	8159500	0	8159500	42154500
6	5000	22500000	1071400	25400	625000	0.0	8023900	0	8023900	50178400
7	5000	22500000	1071400	25400	625000	0.0	7888200	0	7888200	58066600
8	5000	22500000	1071400	25400	625000	0.0	7752500	0	7752500	65819100
9	5000	22500000	1071400	25400	625000	0.0	7616800	0	7616800	73435900
10	5000	22500000	1071400	25400	625000	0.0	7481100	0	7481100	80917000
11	5000	22500000	1071400	25400	625000	0.0	7345400	0	7345400	88262400
12	5000	22500000	1071400	25400	625000	0.0	7209700	0	7209700	95472100
13	5000	22500000	1071400	25400	625000	0.0	7074000	0	7074000	102546100
14	5000	22500000	1071400	25400	625000	0.0	6938300	0	6938300	109484400
15	5000	22500000	1071400	25400	625000	0.0	6802600	0	6802600	116287000
16	5000	22500000	1071400	25400	625000	0.0	6667000	0	6667000	122954000
17	5000	22500000	1071400	25400	625000	0.0	6531300	0	6531300	129485300
18	5000	22500000	1071400	25400	625000	0.0	6395600	0	6395600	135880900
19	5000	22500000	1071400	25400	625000	0.0	6259900	0	6259900	142140800
20	5000	22500000	1071400	25400	625000	0.0	6124200	0	6124200	148265000
21	5000	22500000	1071400	25400	625000	0.0	5988500	0	5988500	154253500
22	5000	22500000	1071400	25400	625000	0.0	5852800	0	5852800	160106300
23	5000	22500000	1071400	25400	625000	0.0	5717100	0	5717100	165823400
24	5000	22500000	1071400	25400	625000	0.0	5581400	0	5581400	171404800
25	5000	22500000	1071400	25400	625000	0.0	5445700	0	5445700	176850500
26	5000	22500000	1071400	25400	625000	0.0	5310000	0	5310000	182160500
27	5000	22500000	1071400	25400	625000	0.0	5174400	0	5174400	187334900
28	5000	22500000	1071400	25400	625000	0.0	5038700	0	5038700	192373600
29	5000	22500000	1071400	25400	625000	0.0	4903000	0	4903000	197276600
30	5000	22500000	1071400	25400	625000	0.0	4767300	0	4767300	202043900
TOT	150000	675000000	32142000	762000	18750000		202043900	0	202043900	

LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST			
DOLLARS PER TON OF COAL BURNED	6.29	0.0	6.29
MILLS PER KILOWATT-HOUR	2.69	0.0	2.69
CENTS PER MILLION BTU HEAT INPUT	29.93	0.0	29.93
DOLLARS PER TON OF SULFUR REMOVED	265.15	0.0	265.15
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS	63826800	0	63826800
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT			
DOLLARS PER TON OF COAL BURNED	7.18	0.0	7.18
MILLS PER KILOWATT-HOUR	3.08	0.0	3.08
CENTS PER MILLION BTU HEAT INPUT	34.18	0.0	34.18
DOLLARS PER TON OF SULFUR REMOVED	302.78	0.0	302.78

TABLE C-11

LIME/LIMESTONE SLUDGE DISPOSAL - DRAVO PROCESS, 1500 MW NEW UNIT, 3.5% S, 7000 HRS CONSTANT ONSTEAM, REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 62551000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	7000	94500000	4500000	106800	2625000	0.0	22624000	0	22624000	22624000
2	7000	94500000	4500000	106800	2625000	0.0	22302800	0	22302800	44926800
3	7000	94500000	4500000	106800	2625000	0.0	21981600	0	21981600	66908400
4	7000	94500000	4500000	106800	2625000	0.0	21660300	0	21660300	88568700
5	7000	94500000	4500000	106800	2625000	0.0	21339100	0	21339100	109907800
6	7000	94500000	4500000	106800	2625000	0.0	21017900	0	21017900	130925700
7	7000	94500000	4500000	106800	2625000	0.0	20696700	0	20696700	151622400
8	7000	94500000	4500000	106800	2625000	0.0	20375500	0	20375500	171997900
9	7000	94500000	4500000	106800	2625000	0.0	20054300	0	20054300	192052200
10	7000	94500000	4500000	106800	2625000	0.0	19733100	0	19733100	211785300
11	7000	94500000	4500000	106800	2625000	0.0	19411900	0	19411900	231197200
12	7000	94500000	4500000	106800	2625000	0.0	19090700	0	19090700	250287900
13	7000	94500000	4500000	106800	2625000	0.0	18769500	0	18769500	269057400
14	7000	94500000	4500000	106800	2625000	0.0	18448200	0	18448200	287505600
15	7000	94500000	4500000	106800	2625000	0.0	18127000	0	18127000	305632600
16	7000	94500000	4500000	106800	2625000	0.0	17805800	0	17805800	323438400
17	7000	94500000	4500000	106800	2625000	0.0	17484600	0	17484600	340923000
18	7000	94500000	4500000	106800	2625000	0.0	17163400	0	17163400	358086400
19	7000	94500000	4500000	106800	2625000	0.0	16842200	0	16842200	374928600
20	7000	94500000	4500000	106800	2625000	0.0	16521000	0	16521000	391449600
21	7000	94500000	4500000	106800	2625000	0.0	16199800	0	16199800	407649400
22	7000	94500000	4500000	106800	2625000	0.0	15878600	0	15878600	423528000
23	7000	94500000	4500000	106800	2625000	0.0	15557400	0	15557400	439085400
24	7000	94500000	4500000	106800	2625000	0.0	15236100	0	15236100	454321500
25	7000	94500000	4500000	106800	2625000	0.0	14914900	0	14914900	469236400
26	7000	94500000	4500000	106800	2625000	0.0	14593700	0	14593700	483830100
27	7000	94500000	4500000	106800	2625000	0.0	14272500	0	14272500	498102600
28	7000	94500000	4500000	106800	2625000	0.0	13951300	0	13951300	512053900
29	7000	94500000	4500000	106800	2625000	0.0	13630100	0	13630100	525684000
30	7000	94500000	4500000	106800	2625000	0.0	13308900	0	13308900	538992900
TOT	210000	2835000000	135000000	3204000	78750000		538992900	0	538992900	
LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST										
DOLLARS PER TON OF COAL BURNED							3.99	0.0	3.99	
MILLS PER KILOWATT-HOUR							1.71	0.0	1.71	
CENTS PER MILLION BTU HEAT INPUT							19.01	0.0	19.01	
DOLLARS PER TON OF SULFUR REMOVED							168.23	0.0	168.23	
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS							167889600	0	167889600	
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT										
DOLLARS PER TON OF COAL BURNED							4.49	0.0	4.49	
MILLS PER KILOWATT-HOUR							1.93	0.0	1.93	
CENTS PER MILLION BTU HEAT INPUT							21.40	0.0	21.40	
DOLLARS PER TON OF SULFUR REMOVED							189.38	0.0	189.38	

TABLE C-12

LIME/LIMESTONE SLUDGE DISPOSAL - DRAVO PROCESS, 1500 MW NEW UNIT, 3.5% S, 5000 HRS CONSTANT ONSTEAM, REGULATED CO. ECONOMICS

FIXED INVESTMENT:, $ 51998000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	5000	67500000	3214300	76300	1875000	0.0	18314900	0	18314900	18314900
2	5000	67500000	3214300	76300	1875000	0.0	18045400	0	18045400	36360300
3	5000	67500000	3214300	76300	1875000	0.0	17775900	0	17775900	54136200
4	5000	67500000	3214300	76300	1875000	0.0	17506500	0	17506500	71642700
5	5000	67500000	3214300	76300	1875000	0.0	17237000	0	17237000	88879700
6	5000	67500000	3214300	76300	1875000	0.0	16967600	0	16967600	105847300
7	5000	67500000	3214300	76300	1875000	0.0	16698100	0	16698100	122545400
8	5000	67500000	3214300	76300	1875000	0.0	16428700	0	16428700	138974100
9	5000	67500000	3214300	76300	1875000	0.0	16159200	0	16159200	155133300
10	5000	67500000	3214300	76300	1875000	0.0	15889800	0	15889800	171023100
11	5000	67500000	3214300	76300	1875000	0.0	15620300	0	15620300	186643400
12	5000	67500000	3214300	76300	1875000	0.0	15350800	0	15350800	201994200
13	5000	67500000	3214300	76300	1875000	0.0	15081400	0	15081400	217075600
14	5000	67500000	3214300	76300	1875000	0.0	14811900	0	14811900	231887500
15	5000	67500000	3214300	76300	1875000	0.0	14542500	0	14542500	246430000
16	5000	67500000	3214300	76300	1875000	0.0	14273000	0	14273000	260703000
17	5000	67500000	3214300	76300	1875000	0.0	14003600	0	14003600	274706600
18	5000	67500000	3214300	76300	1875000	0.0	13734100	0	13734100	288440700
19	5000	67500000	3214300	76300	1875000	0.0	13464700	0	13464700	301905400
20	5000	67500000	3214300	76300	1875000	0.0	13195200	0	13195200	315100600
21	5000	67500000	3214300	76300	1875000	0.0	12925800	0	12925800	328026400
22	5000	67500000	3214300	76300	1875000	0.0	12656300	0	12656300	340682700
23	5000	67500000	3214300	76300	1875000	0.0	12386800	0	12386800	353069500
24	5000	67500000	3214300	76300	1875000	0.0	12117400	0	12117400	365186900
25	5000	67500000	3214300	76300	1875000	0.0	11847900	0	11847900	377034800
26	5000	67500000	3214300	76300	1875000	0.0	11578500	0	11578500	388613300
27	5000	67500000	3214300	76300	1875000	0.0	11309000	0	11309000	399922300
28	5000	67500000	3214300	76300	1875000	0.0	11039600	0	11039600	410961900
29	5000	67500000	3214300	76300	1875000	0.0	10770100	0	10770100	421732000
30	5000	67500000	3214300	76300	1875000	0.0	10500700	0	10500700	432232700
TOT	150000	2025000000	96429000	2289000	56250000		432232700	0	432232700	
LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST										
DOLLARS PER TON OF COAL BURNED							4.48	0.0	4.48	
MILLS PER KILOWATT-HOUR							1.92	0.0	1.92	
CENTS PER MILLION BTU HEAT INPUT							21.34	0.0	21.34	
DOLLARS PER TON OF SULFUR REMOVED							188.83	0.0	188.83	
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS							135328300	0	135328300	
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT										
DOLLARS PER TON OF COAL BURNED							5.07	0.0	5.07	
MILLS PER KILOWATT-HOUR							2.17	0.0	2.17	
CENTS PER MILLION BTU HEAT INPUT							24.15	0.0	24.15	
DOLLARS PER TON OF SULFUR REMOVED							213.69	0.0	213.69	

TABLE C-13

LIME/LIMESTONE SLUDGE DISPOSAL - IUCS PROCESS, 200 MW NEW UNIT, 3.5% S, 7000 HRS CONSTANT ONSTEAM, REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 7369000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	7000	12880000	613300	14600	283500	0.0	4259000	0	4259000	4259000
2	7000	12880000	613300	14600	283500	0.0	4221300	0	4221300	8480300
3	7000	12880000	613300	14600	283500	0.0	4183700	0	4183700	12664000
4	7000	12880000	613300	14600	283500	0.0	4146100	0	4146100	16810100
5	7000	12880000	613300	14600	283500	0.0	4108400	0	4108400	20918500
6	7000	12880000	613300	14600	283500	0.0	4070800	0	4070800	24989300
7	7000	12880000	613300	14600	283500	0.0	4033200	0	4033200	29022500
8	7000	12880000	613300	14600	283500	0.0	3995500	0	3995500	33018000
9	7000	12880000	613300	14600	283500	0.0	3957900	0	3957900	36975900
10	7000	12880000	613300	14600	283500	0.0	3920300	0	3920300	40896200
11	7000	12880000	613300	14600	283500	0.0	3882600	0	3882600	44778800
12	7000	12880000	613300	14600	283500	0.0	3845000	0	3845000	48623800
13	7000	12880000	613300	14600	283500	0.0	3807400	0	3807400	52431200
14	7000	12880000	613300	14600	283500	0.0	3769700	0	3769700	56200900
15	7000	12880000	613300	14600	283500	0.0	3732100	0	3732100	59933000
16	7000	12880000	613300	14600	283500	0.0	3694500	0	3694500	63627500
17	7000	12880000	613300	14600	283500	0.0	3656800	0	3656800	67284300
18	7000	12880000	613300	14600	283500	0.0	3619200	0	3619200	70903500
19	7000	12880000	613300	14600	283500	0.0	3581600	0	3581600	74485100
20	7000	12880000	613300	14600	283500	0.0	3543900	0	3543900	78029000
21	7000	12880000	613300	14600	283500	0.0	3506300	0	3506300	81535300
22	7000	12880000	613300	14600	283500	0.0	3468700	0	3468700	85004000
23	7000	12880000	613300	14600	283500	0.0	3431000	0	3431000	88435000
24	7000	12880000	613300	14600	283500	0.0	3393400	0	3393400	91828400
25	7000	12880000	613300	14600	283500	0.0	3355800	0	3355800	95184200
26	7000	12880000	613300	14600	283500	0.0	3318100	0	3318100	98502300
27	7000	12880000	613300	14600	283500	0.0	3280500	0	3280500	101782800
28	7000	12880000	613300	14600	283500	0.0	3242900	0	3242900	105025700
29	7000	12880000	613300	14600	283500	0.0	3205200	0	3205200	108230900
30	7000	12880000	613300	14600	283500	0.0	3167600	0	3167600	111398500
TOT	210000	386400000	18399000	438000	8505000		111398500	0	111398500	

LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST			
DOLLARS PER TON OF COAL BURNED	6.05	0.0	6.05
MILLS PER KILOWATT-HOUR	2.65	0.0	2.65
CENTS PER MILLION BTU HEAT INPUT	28.83	0.0	28.83
DOLLARS PER TON OF SULFUR REMOVED	254.33	0.0	254.33
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS	33019700	0	33019700
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT			
DOLLARS PER TON OF COAL BURNED	6.49	0.0	6.49
MILLS PER KILOWATT-HOUR	2.84	0.0	2.84
CENTS PER MILLION BTU HEAT INPUT	30.89	0.0	30.89
DOLLARS PER TON OF SULFUR REMOVED	272.44	0.0	272.44

TABLE C-14

LIME/LIMESTONE SLUDGE DISPOSAL - IUCS PROCESS, 200 MW NEW UNIT, 3.5% S, 5000 HRS CONSTANT ONSTEAM, REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 7214000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	5000	9200000	438100	10400	202500	0.0	4075600	0	4075600	4075600
2	5000	9200000	438100	10400	202500	0.0	4038000	0	4038000	8113600
3	5000	9200000	438100	10400	202500	0.0	4000300	0	4000300	12113900
4	5000	9200000	438100	10400	202500	0.0	3962700	0	3962700	16076600
5	5000	9200000	438100	10400	202500	0.0	3925100	0	3925100	20001700
6	5000	9200000	438100	10400	202500	0.0	3887400	0	3887400	23889100
7	5000	9200000	438100	10400	202500	0.0	3849800	0	3849800	27738900
8	5000	9200000	438100	10400	202500	0.0	3812200	0	3812200	31551100
9	5000	9200000	438100	10400	202500	0.0	3774500	0	3774500	35325600
10	5000	9200000	438100	10400	202500	0.0	3736900	0	3736900	39062500
11	5000	9200000	438100	10400	202500	0.0	3699300	0	3699300	42761800
12	5000	9200000	438100	10400	202500	0.0	3661600	0	3661600	46423400
13	5000	9200000	438100	10400	202500	0.0	3624000	0	3624000	50047400
14	5000	9200000	438100	10400	202500	0.0	3586400	0	3586400	53633800
15	5000	9200000	438100	10400	202500	0.0	3548700	0	3548700	57182500
16	5000	9200000	438100	10400	202500	0.0	3511100	0	3511100	60693600
17	5000	9200000	438100	10400	202500	0.0	3473500	0	3473500	64167100
18	5000	9200000	438100	10400	202500	0.0	3435800	0	3435800	67602900
19	5000	9200000	438100	10400	202500	0.0	3398200	0	3398200	71001100
20	5000	9200000	438100	10400	202500	0.0	3360600	0	3360600	74361700
21	5000	9200000	438100	10400	202500	0.0	3322900	0	3322900	77684600
22	5000	9200000	438100	10400	202500	0.0	3285300	0	3285300	80969900
23	5000	9200000	438100	10400	202500	0.0	3247700	0	3247700	84217600
24	5000	9200000	438100	10400	202500	0.0	3210000	0	3210000	87427600
25	5000	9200000	438100	10400	202500	0.0	3172400	0	3172400	90600000
26	5000	9200000	438100	10400	202500	0.0	3134800	0	3134800	93734800
27	5000	9200000	438100	10400	202500	0.0	3097100	0	3097100	96831900
28	5000	9200000	438100	10400	202500	0.0	3059500	0	3059500	99891400
29	5000	9200000	438100	10400	202500	0.0	3021900	0	3021900	102913300
30	5000	9200000	438100	10400	202500	0.0	2984200	0	2984200	105897500
TOT	150000	276000000	13143000	312000	6075000		105897500	0	105897500	

LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST			
DOLLARS PER TON OF COAL BURNED	8.06	0.0	8.06
MILLS PER KILOWATT-HOUR	3.53	0.0	3.53
CENTS PER MILLION BTU HEAT INPUT	38.37	0.0	38.37
DOLLARS PER TON OF SULFUR REMOVED	339.42	0.0	339.42
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS	31497700	0	31497700
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT			
DOLLARS PER TON OF COAL BURNED	8.66	0.0	8.66
MILLS PER KILOWATT-HOUR	3.79	0.0	3.79
CENTS PER MILLION BTU HEAT INPUT	41.25	0.0	41.25
DOLLARS PER TON OF SULFUR REMOVED	364.98	0.0	364.98

TABLE C-15

LIME/LIMESTONE SLUDGE DISPOSAL - IUCS PROCESS, 500 MW NEW UNIT, 3.5% S, 7000 HRS CONSTANT ONSTEAM, REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 11159000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	7000	31500000	1500000	35600	693000	0.0	6377900	0	6377900	6377900
2	7000	31500000	1500000	35600	693000	0.0	6323500	0	6323500	12701400
3	7000	31500000	1500000	35600	693000	0.0	6269000	0	6269000	18970400
4	7000	31500000	1500000	35600	693000	0.0	6214500	0	6214500	25184900
5	7000	31500000	1500000	35600	693000	0.0	6160000	0	6160000	31344900
6	7000	31500000	1500000	35600	693000	0.0	6105500	0	6105500	37450400
7	7000	31500000	1500000	35600	693000	0.0	6051000	0	6051000	43501400
8	7000	31500000	1500000	35600	693000	0.0	5996500	0	5996500	49497900
9	7000	31500000	1500000	35600	693000	0.0	5942000	0	5942000	55439900
10	7000	31500000	1500000	35600	693000	0.0	5887500	0	5887500	61327400
11	7000	31500000	1500000	35600	693000	0.0	5833100	0	5833100	67160500
12	7000	31500000	1500000	35600	693000	0.0	5778600	0	5778600	72939100
13	7000	31500000	1500000	35600	693000	0.0	5724100	0	5724100	78663200
14	7000	31500000	1500000	35600	693000	0.0	5669600	0	5669600	84332800
15	7000	31500000	1500000	35600	693000	0.0	5615100	0	5615100	89947900
16	7000	31500000	1500000	35600	693000	0.0	5560600	0	5560600	95508500
17	7000	31500000	1500000	35600	693000	0.0	5506100	0	5506100	101014600
18	7000	31500000	1500000	35600	693000	0.0	5451600	0	5451600	106466200
19	7000	31500000	1500000	35600	693000	0.0	5397100	0	5397100	111863300
20	7000	31500000	1500000	35600	693000	0.0	5342600	0	5342600	117205900
21	7000	31500000	1500000	35600	693000	0.0	5288200	0	5288200	122494100
22	7000	31500000	1500000	35600	693000	0.0	5233700	0	5233700	127727800
23	7000	31500000	1500000	35600	693000	0.0	5179200	0	5179200	132907000
24	7000	31500000	1500000	35600	693000	0.0	5124700	0	5124700	138031700
25	7000	31500000	1500000	35600	693000	0.0	5070200	0	5070200	143101900
26	7000	31500000	1500000	35600	693000	0.0	5015700	0	5015700	148117600
27	7000	31500000	1500000	35600	693000	0.0	4961200	0	4961200	153078800
28	7000	31500000	1500000	35600	693000	0.0	4906700	0	4906700	157985500
29	7000	31500000	1500000	35600	693000	0.0	4852200	0	4852200	162837700
30	7000	31500000	1500000	35600	693000	0.0	4797700	0	4797700	167635400
TOT	210000	945000000	45000000	1068000	20790000		167635400	0	167635400	
LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST										
DOLLARS PER TON OF COAL BURNED							3.73	0.0	3.73	
MILLS PER KILOWATT-HOUR							1.60	0.0	1.60	
CENTS PER MILLION BTU HEAT INPUT							17.74	0.0	17.74	
DOLLARS PER TON OF SULFUR REMOVED							156.96	0.0	156.96	
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS							49563800	0	49563800	
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT										
DOLLARS PER TON OF COAL BURNED							3.98	0.0	3.98	
MILLS PER KILOWATT-HOUR							1.71	0.0	1.71	
CENTS PER MILLION BTU HEAT INPUT							18.96	0.0	18.96	
DOLLARS PER TON OF SULFUR REMOVED							167.73	0.0	167.73	

TABLE C-16

LIME/LIMESTONE SLUDGE DISPOSAL - IUCS PROCESS, 500 MW NEW UNIT, 3.5% S, 5000 HRS CONSTANT ONSTEAM REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 10779000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	5000	22500000	1071400	25400	495000	0.0	5946200	0	5946200	5946200
2	5000	22500000	1071400	25400	495000	0.0	5891700	0	5891700	11837900
3	5000	22500000	1071400	25400	495000	0.0	5837200	0	5837200	17675100
4	5000	22500000	1071400	25400	495000	0.0	5782700	0	5782700	23457800
5	5000	22500000	1071400	25400	495000	0.0	5728200	0	5728200	29186000
6	5000	22500000	1071400	25400	495000	0.0	5673700	0	5673700	34859700
7	5000	22500000	1071400	25400	495000	0.0	5619300	0	5619300	40479000
8	5000	22500000	1071400	25400	495000	0.0	5564800	0	5564800	46043800
9	5000	22500000	1071400	25400	495000	0.0	5510300	0	5510300	51554100
10	5000	22500000	1071400	25400	495000	0.0	5455800	0	5455800	57009900
11	5000	22500000	1071400	25400	495000	0.0	5401300	0	5401300	62411200
12	5000	22500000	1071400	25400	495000	0.0	5346800	0	5346800	67758000
13	5000	22500000	1071400	25400	495000	0.0	5292300	0	5292300	73050300
14	5000	22500000	1071400	25400	495000	0.0	5237800	0	5237800	78288100
15	5000	22500000	1071400	25400	495000	0.0	5183300	0	5183300	83471400
16	5000	22500000	1071400	25400	495000	0.0	5128800	0	5128800	88600200
17	5000	22500000	1071400	25400	495000	0.0	5074400	0	5074400	93674600
18	5000	22500000	1071400	25400	495000	0.0	5019900	0	5019900	98694500
19	5000	22500000	1071400	25400	495000	0.0	4965400	0	4965400	103659900
20	5000	22500000	1071400	25400	495000	0.0	4910900	0	4910900	108570800
21	5000	22500000	1071400	25400	495000	0.0	4856400	0	4856400	113427200
22	5000	22500000	1071400	25400	495000	0.0	4801900	0	4801900	118229100
23	5000	22500000	1071400	25400	495000	0.0	4747400	0	4747400	122976500
24	5000	22500000	1071400	25400	495000	0.0	4692900	0	4692900	127669400
25	5000	22500000	1071400	25400	495000	0.0	4638400	0	4638400	132307800
26	5000	22500000	1071400	25400	495000	0.0	4583900	0	4583900	136891700
27	5000	22500000	1071400	25400	495000	0.0	4529500	0	4529500	141421200
28	5000	22500000	1071400	25400	495000	0.0	4475000	0	4475000	145896200
29	5000	22500000	1071400	25400	495000	0.0	4420500	0	4420500	150316700
30	5000	22500000	1071400	25400	495000	0.0	4366000	0	4366000	154682700
TOT	150000	675000000	32142000	762000	14850000		154682700	0	154682700	
LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST										
DOLLARS PER TON OF COAL BURNED							4.81	0.0	4.81	
MILLS PER KILOWATT-HOUR							2.06	0.0	2.06	
CENTS PER MILLION BTU HEAT INPUT							22.92	0.0	22.92	
DOLLARS PER TON OF SULFUR REMOVED							203.00	0.0	203.00	
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS							45980100	0	45980100	
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT										
DOLLARS PER TON OF COAL BURNED							5.17	0.0	5.17	
MILLS PER KILOWATT-HOUR							2.22	0.0	2.22	
CENTS PER MILLION BTU HEAT INPUT							24.62	0.0	24.62	
DOLLARS PER TON OF SULFUR REMOVED							218.12	0.0	218.12	

TABLE C-17

LIME/LIMESTONE SLUDGE DISPOSAL - IUCS PROCESS, 1500 MW NEW UNIT, 3.5% S, 7000 HRS CONSTANT ONSTEAM, REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 21415000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	7000	94500000	4500000	106800	2075500	0.0	12605800	0	12605800	12605800
2	7000	94500000	4500000	106800	2075500	0.0	12508700	0	12508700	25114500
3	7000	94500000	4500000	106800	2075500	0.0	12411600	0	12411600	37526100
4	7000	94500000	4500000	106800	2075500	0.0	12314500	0	12314500	49840600
5	7000	94500000	4500000	106800	2075500	0.0	12217400	0	12217400	62058000
6	7000	94500000	4500000	106800	2075500	0.0	12120300	0	12120300	74178300
7	7000	94500000	4500000	106800	2075500	0.0	12023200	0	12023200	86201500
8	7000	94500000	4500000	106800	2075500	0.0	11926100	0	11926100	98127600
9	7000	94500000	4500000	106800	2075500	0.0	11829000	0	11829000	109956600
10	7000	94500000	4500000	106800	2075500	0.0	11731900	0	11731900	121688500
11	7000	94500000	4500000	106800	2075500	0.0	11634800	0	11634800	133323300
12	7000	94500000	4500000	106800	2075500	0.0	11537700	0	11537700	144861000
13	7000	94500000	4500000	106800	2075500	0.0	11440700	0	11440700	156301700
14	7000	94500000	4500000	106800	2075500	0.0	11343600	0	11343600	167645300
15	7000	94500000	4500000	106800	2075500	0.0	11246500	0	11246500	178891800
16	7000	94500000	4500000	106800	2075500	0.0	11149400	0	11149400	190041200
17	7000	94500000	4500000	106800	2075500	0.0	11052300	0	11052300	201093500
18	7000	94500000	4500000	106800	2075500	0.0	10955200	0	10955200	212048700
19	7000	94500000	4500000	106800	2075500	0.0	10858100	0	10858100	222906800
20	7000	94500000	4500000	106800	2075500	0.0	10761000	0	10761000	233667800
21	7000	94500000	4500000	106800	2075500	0.0	10663900	0	10663900	244331700
22	7000	94500000	4500000	106800	2075500	0.0	10566800	0	10566800	254898500
23	7000	94500000	4500000	106800	2075500	0.0	10469700	0	10469700	265368200
24	7000	94500000	4500000	106800	2075500	0.0	10372600	0	10372600	275740800
25	7000	94500000	4500000	106800	2075500	0.0	10275500	0	10275500	286016300
26	7000	94500000	4500000	106800	2075500	0.0	10178400	0	10178400	296194700
27	7000	94500000	4500000	106800	2075500	0.0	10081300	0	10081300	306276000
28	7000	94500000	4500000	106800	2075500	0.0	9984200	0	9984200	316260200
29	7000	94500000	4500000	106800	2075500	0.0	9887100	0	9887100	326147300
30	7000	94500000	4500000	106800	2075500	0.0	9790100	0	9790100	335937600
TOT	210000	2835000000	135000000	3204000	62265000		335937400	0	335937400	
LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST										
DOLLARS PER TON OF COAL BURNED							2.49	0.0	2.49	
MILLS PER KILOWATT-HOUR							1.07	0.0	1.07	
CENTS PER MILLION BTU HEAT INPUT							11.85	0.0	11.85	
DOLLARS PER TON OF SULFUR REMOVED							104.85	0.0	104.85	
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS							98617900	0	98617900	
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT										
DOLLARS PER TON OF COAL BURNED							2.64	0.0	2.64	
MILLS PER KILOWATT-HOUR							1.13	0.0	1.13	
CENTS PER MILLION BTU HEAT INPUT							12.57	0.0	12.57	
DOLLARS PER TON OF SULFUR REMOVED							111.24	0.0	111.24	

TABLE C-18

LIME/LIMESTONE SLUDGE DISPOSAL - IUCS PROCESS, 1500 MW NEW UNIT 3.5% S, 5000 HRS CONSTANT ONSTEAM REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 20282000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/ KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	5000	67500000	3214300	76300	1482500	0.0	11328900	0	11328900	11328900
2	5000	67500000	3214300	76300	1482500	0.0	11231800	0	11231800	22560700
3	5000	67500000	3214300	76300	1482500	0.0	11134700	0	11134700	33695400
4	5000	67500000	3214300	76300	1482500	0.0	11037600	0	11037600	44733000
5	5000	67500000	3214300	76300	1482500	0.0	10940500	0	10940500	55673500
6	5000	67500000	3214300	76300	1482500	0.0	10843400	0	10843400	66516900
7	5000	67500000	3214300	76300	1482500	0.0	10746300	0	10746300	77263200
8	5000	67500000	3214300	76300	1482500	0.0	10649200	0	10649200	87912400
9	5000	67500000	3214300	76300	1482500	0.0	10552200	0	10552200	98464600
10	5000	67500000	3214300	76300	1482500	0.0	10455100	0	10455100	108919700
11	5000	67500000	3214300	76300	1482500	0.0	10358000	0	10358000	119277700
12	5000	67500000	3214300	76300	1482500	0.0	10260900	0	10260900	129538600
13	5000	67500000	3214300	76300	1482500	0.0	10163800	0	10163800	139702400
14	5000	67500000	3214300	76300	1482500	0.0	10066700	0	10066700	149769100
15	5000	67500000	3214300	76300	1482500	0.0	9969600	0	9969600	159738700
16	5000	67500000	3214300	76300	1482500	0.0	9872500	0	9872500	169611200
17	5000	67500000	3214300	76300	1482500	0.0	9775400	0	9775400	179386600
18	5000	67500000	3214300	76300	1482500	0.0	9678300	0	9678300	189064900
19	5000	67500000	3214300	76300	1482500	0.0	9581200	0	9581200	198646100
20	5000	67500000	3214300	76300	1482500	0.0	9484100	0	9484100	208130200
21	5000	67500000	3214300	76300	1482500	0.0	9387000	0	9387000	217517200
22	5000	67500000	3214300	76300	1482500	0.0	9289900	0	9289900	226807100
23	5000	67500000	3214300	76300	1482500	0.0	9192800	0	9192800	235999900
24	5000	67500000	3214300	76300	1482500	0.0	9095700	0	9095700	245095600
25	5000	67500000	3214300	76300	1482500	0.0	8998600	0	8998600	254094200
26	5000	67500000	3214300	76300	1482500	0.0	8901600	0	8901600	262995800
27	5000	67500000	3214300	76300	1482500	0.0	8804500	0	8804500	271800300
28	5000	67500000	3214300	76300	1482500	0.0	8707400	0	8707400	280507700
29	5000	67500000	3214300	76300	1482500	0.0	8610300	0	8610300	289118000
30	5000	67500000	3214300	76300	1482500	0.0	8513200	0	8513200	297631200
TOT	150000	2025000000	96429000	2289000	44475000		297631200	0	297631200	
LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST										
DOLLARS PER TON OF COAL BURNED							3.09	0.0	3.09	
MILLS PER KILOWATT-HOUR							1.32	0.0	1.32	
CENTS PER MILLION BTU HEAT INPUT							14.70	0.0	14.70	
DOLLARS PER TON OF SULFUR REMOVED							130.03	0.0	130.03	
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS							88019300	0	88019300	
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT										
DOLLARS PER TON OF COAL BURNED							3.30	0.0	3.30	
MILLS PER KILOWATT-HOUR							1.41	0.0	1.41	
CENTS PER MILLION BTU HEAT INPUT							15.71	0.0	15.71	
DOLLARS PER TON OF SULFUR REMOVED							138.99	0.0	138.99	

TABLE C-19

LIME/LIMESTONE SLUDGE DISPOSAL - CHEMFIX PROCESS, 200 MW NEW UNIT, 3.5% S, 7000 HRS CONSTANT ONSTEAM, REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 9432000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	7000	12880000	613300	14600	290500	0.0	5404600	0	5404600	5404600
2	7000	12880000	613300	14600	290500	0.0	5355900	0	5355900	10760500
3	7000	12880000	613300	14600	290500	0.0	5307100	0	5307100	16067600
4	7000	12880000	613300	14600	290500	0.0	5258400	0	5258400	21326000
5	7000	12880000	613300	14600	290500	0.0	5209600	0	5209600	26535600
6	7000	12880000	613300	14600	290500	0.0	5160900	0	5160900	31696500
7	7000	12880000	613300	14600	290500	0.0	5112100	0	5112100	36808600
8	7000	12880000	613300	14600	290500	0.0	5063400	0	5063400	41872000
9	7000	12880000	613300	14600	290500	0.0	5014600	0	5014600	46886600
10	7000	12880000	613300	14600	290500	0.0	4965900	0	4965900	51852500
11	7000	12880000	613300	14600	290500	0.0	4917200	0	4917200	56769700
12	7000	12880000	613300	14600	290500	0.0	4868400	0	4868400	61638100
13	7000	12880000	613300	14600	290500	0.0	4819700	0	4819700	66457800
14	7000	12880000	613300	14600	290500	0.0	4770900	0	4770900	71228700
15	7000	12880000	613300	14600	290500	0.0	4722200	0	4722200	75950900
16	7000	12880000	613300	14600	290500	0.0	4673400	0	4673400	80624300
17	7000	12880000	613300	14600	290500	0.0	4624700	0	4624700	85249000
18	7000	12880000	613300	14600	290500	0.0	4575900	0	4575900	89824900
19	7000	12880000	613300	14600	290500	0.0	4527200	0	4527200	94352100
20	7000	12880000	613300	14600	290500	0.0	4478500	0	4478500	98830600
21	7000	12880000	613300	14600	290500	0.0	4429700	0	4429700	103260300
22	7000	12880000	613300	14600	290500	0.0	4381000	0	4381000	107641300
23	7000	12880000	613300	14600	290500	0.0	4332200	0	4332200	111973500
24	7000	12880000	613300	14600	290500	0.0	4283500	0	4283500	116257000
25	7000	12880000	613300	14600	290500	0.0	4234700	0	4234700	120491700
26	7000	12880000	613300	14600	290500	0.0	4186000	0	4186000	124677700
27	7000	12880000	613300	14600	290500	0.0	4137200	0	4137200	128814900
28	7000	12880000	613300	14600	290500	0.0	4088500	0	4088500	132903400
29	7000	12880000	613300	14600	290500	0.0	4039700	0	4039700	136943100
30	7000	12880000	613300	14600	290500	0.0	3991000	0	3991000	140934100
TOT	210000	386400000	18399000	438000	8715000		140934100	0	140934100	

LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST			
DOLLARS PER TON OF COAL BURNED	7.66	0.0	7.66
MILLS PER KILOWATT-HOUR	3.36	0.0	3.36
CENTS PER MILLION BTU HEAT INPUT	36.47	0.0	36.47
DOLLARS PER TON OF SULFUR REMOVED	321.77	0.0	321.77
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS	41840600	0	41840600
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT			
DOLLARS PER TON OF COAL BURNED	8.22	0.0	8.22
MILLS PER KILOWATT-HOUR	3.60	0.0	3.60
CENTS PER MILLION BTU HEAT INPUT	39.14	0.0	39.14
DOLLARS PER TON OF SULFUR REMOVED	345.22	0.0	345.22

TABLE C-20

LIME/LIMESTONE SLUDGE DISPOSAL - CHEMFIX PROCESS, 200 MW NEW UNIT, 3.5% S, 5000 HRS CONSTANT ONSTEAM, REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 9274000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	5000	9200000	438100	10400	507500	0.0	5226100	0	5226100	5226100
2	5000	9200000	438100	10400	507500	0.0	5177400	0	5177400	10403500
3	5000	9200000	438100	10400	507500	0.0	5128600	0	5128600	15532100
4	5000	9200000	438100	10400	507500	0.0	5079900	0	5079900	20612000
5	5000	9200000	438100	10400	507500	0.0	5031100	0	5031100	25643100
6	5000	9200000	438100	10400	507500	0.0	4982400	0	4982400	30625500
7	5000	9200000	438100	10400	507500	0.0	4933700	0	4933700	35559200
8	5000	9200000	438100	10400	507500	0.0	4884900	0	4884900	40444100
9	5000	9200000	438100	10400	507500	0.0	4836200	0	4836200	45280300
10	5000	9200000	438100	10400	507500	0.0	4787400	0	4787400	50067700
11	5000	9200000	438100	10400	507500	0.0	4738700	0	4738700	54806400
12	5000	9200000	438100	10400	507500	0.0	4689900	0	4689900	59496300
13	5000	9200000	438100	10400	507500	0.0	4641200	0	4641200	64137500
14	5000	9200000	438100	10400	507500	0.0	4592400	0	4592400	68729900
15	5000	9200000	438100	10400	507500	0.0	4543700	0	4543700	73273600
16	5000	9200000	438100	10400	507500	0.0	4495000	0	4495000	77768600
17	5000	9200000	438100	10400	507500	0.0	4446200	0	4446200	82214800
18	5000	9200000	438100	10400	507500	0.0	4397500	0	4397500	86612300
19	5000	9200000	438100	10400	507500	0.0	4348700	0	4348700	90961000
20	5000	9200000	438100	10400	507500	0.0	4300000	0	4300000	95261000
21	5000	9200000	438100	10400	507500	0.0	4251200	0	4251200	99512200
22	5000	9200000	438100	10400	507500	0.0	4202500	0	4202500	103714700
23	5000	9200000	438100	10400	507500	0.0	4153700	0	4153700	107868400
24	5000	9200000	438100	10400	507500	0.0	4105000	0	4105000	111973400
25	5000	9200000	438100	10400	507500	0.0	4056300	0	4056300	116029700
26	5000	9200000	438100	10400	507500	0.0	4007500	0	4007500	120037200
27	5000	9200000	438100	10400	507500	0.0	3958800	0	3958800	123996000
28	5000	9200000	438100	10400	507500	0.0	3910000	0	3910000	127906000
29	5000	9200000	438100	10400	507500	0.0	3861300	0	3861300	131767300
30	5000	9200000	438100	10400	507500	0.0	3812500	0	3812500	135579800
TOT	150000	276000000	13143000	312000	15225000		135579800	0	135579800	
LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST										
DOLLARS PER TON OF COAL BURNED							10.32	0.0	10.32	
MILLS PER KILOWATT-HOUR							4.52	0.0	4.52	
CENTS PER MILLION BTU HEAT INPUT							49.12	0.0	49.12	
DOLLARS PER TON OF SULFUR REMOVED							434.55	0.0	434.55	
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS							40359100	0	40359100	
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT										
DOLLARS PER TON OF COAL BURNED							11.10	0.0	11.10	
MILLS PER KILOWATT-HOUR							4.86	0.0	4.86	
CENTS PER MILLION BTU HEAT INPUT							52.85	0.0	52.85	
DOLLARS PER TON OF SULFUR REMOVED							467.66	0.0	467.66	

TABLE C-21

LIME/LIMESTONE SLUDGE DISPOSAL - CHEMFIX PROCESS, 500 MW NEW UNIT, 3.5% S, 7000 HRS CONSTANT ONSTEAM REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 13984000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	7000	31500000	1500000	35600	710500	0.0	8331800	0	8331800	8331800
2	7000	31500000	1500000	35600	710500	0.0	8262700	0	8262700	16594500
3	7000	31500000	1500000	35600	710500	0.0	8193600	0	8193600	24788100
4	7000	31500000	1500000	35600	710500	0.0	8124500	0	8124500	32912600
5	7000	31500000	1500000	35600	710500	0.0	8055400	0	8055400	40968000
6	7000	31500000	1500000	35600	710500	0.0	7986300	0	7986300	48954300
7	7000	31500000	1500000	35600	710500	0.0	7917200	0	7917200	56871500
8	7000	31500000	1500000	35600	710500	0.0	7848100	0	7848100	64719600
9	7000	31500000	1500000	35600	710500	0.0	7779000	0	7779000	72498600
10	7000	31500000	1500000	35600	710500	0.0	7709900	0	7709900	80208500
11	7000	31500000	1500000	35600	710500	0.0	7640800	0	7640800	87849300
12	7000	31500000	1500000	35600	710500	0.0	7571600	0	7571600	95420900
13	7000	31500000	1500000	35600	710500	0.0	7502500	0	7502500	102923400
14	7000	31500000	1500000	35600	710500	0.0	7433400	0	7433400	110356800
15	7000	31500000	1500000	35600	710500	0.0	7364300	0	7364300	117721100
16	7000	31500000	1500000	35600	710500	0.0	7295200	0	7295200	125016300
17	7000	31500000	1500000	35600	710500	0.0	7226100	0	7226100	132242400
18	7000	31500000	1500000	35600	710500	0.0	7157000	0	7157000	139399400
19	7000	31500000	1500000	35600	710500	0.0	7087900	0	7087900	146487300
20	7000	31500000	1500000	35600	710500	0.0	7018800	0	7018800	153506100
21	7000	31500000	1500000	35600	710500	0.0	6949700	0	6949700	160455800
22	7000	31500000	1500000	35600	710500	0.0	6880500	0	6880500	167336300
23	7000	31500000	1500000	35600	710500	0.0	6811400	0	6811400	174147700
24	7000	31500000	1500000	35600	710500	0.0	6742300	0	6742300	180890000
25	7000	31500000	1500000	35600	710500	0.0	6673200	0	6673200	187563200
26	7000	31500000	1500000	35600	710500	0.0	6604100	0	6604100	194167300
27	7000	31500000	1500000	35600	710500	0.0	6535000	0	6535000	200702300
28	7000	31500000	1500000	35600	710500	0.0	6465900	0	6465900	207168200
29	7000	31500000	1500000	35600	710500	0.0	6396800	0	6396800	213565000
30	7000	31500000	1500000	35600	710500	0.0	6327700	0	6327700	219892700
TOT	210000	945000000	45000000	1068000	21315000		219892700	0	219892700	

LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST			
DOLLARS PER TON OF COAL BURNED	4.89	0.0	4.89
MILLS PER KILOWATT-HOUR	2.09	0.0	2.09
CENTS PER MILLION BTU HEAT INPUT	23.27	0.0	23.27
DOLLARS PER TON OF SULFUR REMOVED	205.89	0.0	205.89
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS	64876200	0	64876200
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT			
DOLLARS PER TON OF COAL BURNED	5.21	0.0	5.21
MILLS PER KILOWATT-HOUR	2.23	0.0	2.23
CENTS PER MILLION BTU HEAT INPUT	24.81	0.0	24.81
DOLLARS PER TON OF SULFUR REMOVED	219.55	0.0	219.55

TABLE C-22

LIME/LIMESTONE SLUDGE DISPOSAL - CHEMFIX PROCESS, 500 MW NEW UNIT, 3.5% S, 5000 HRS CONSTANT ONSTEAM, REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 13515000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	5000	2250000	107100	25400	507500	0.0	7479100	0	7479100	7479100
2	5000	2250000	107100	25400	507500	0.0	7410000	0	7410000	14889100
3	5000	2250000	107100	25400	507500	0.0	7340900	0	7340900	22230000
4	5000	2250000	107100	25400	507500	0.0	7271800	0	7271800	29501800
5	5000	2250000	107100	25400	507500	0.0	7202600	0	7202600	36704400
6	5000	2250000	107100	25400	507500	0.0	7133500	0	7133500	43837900
7	5000	2250000	107100	25400	507500	0.0	7064400	0	7064400	50902300
8	5000	2250000	107100	25400	507500	0.0	6995300	0	6995300	57897600
9	5000	2250000	107100	25400	507500	0.0	6926200	0	6926200	64823800
10	5000	2250000	107100	25400	507500	0.0	6857100	0	6857100	71680900
11	5000	2250000	107100	25400	507500	0.0	6788000	0	6788000	78468900
12	5000	2250000	107100	25400	507500	0.0	6718900	0	6718900	85187800
13	5000	2250000	107100	25400	507500	0.0	6649800	0	6649800	91837600
14	5000	2250000	107100	25400	507500	0.0	6580700	0	6580700	98418300
15	5000	2250000	107100	25400	507500	0.0	6511500	0	6511500	104929800
16	5000	2250000	107100	25400	507500	0.0	6442400	0	6442400	111372200
17	5000	2250000	107100	25400	507500	0.0	6373300	0	6373300	117745500
18	5000	2250000	107100	25400	507500	0.0	6304200	0	6304200	124049700
19	5000	2250000	107100	25400	507500	0.0	6235100	0	6235100	130284800
20	5000	2250000	107100	25400	507500	0.0	6166000	0	6166000	136450800
21	5000	2250000	107100	25400	507500	0.0	6096900	0	6096900	142547700
22	5000	2250000	107100	25400	507500	0.0	6027800	0	6027800	148575500
23	5000	2250000	107100	25400	507500	0.0	5958700	0	5958700	154534200
24	5000	2250000	107100	25400	507500	0.0	5889600	0	5889600	160423800
25	5000	2250000	107100	25400	507500	0.0	5820400	0	5820400	166244200
26	5000	2250000	107100	25400	507500	0.0	5751300	0	5751300	171995500
27	5000	2250000	107100	25400	507500	0.0	5682200	0	5682200	177677700
28	5000	2250000	107100	25400	507500	0.0	5613100	0	5613100	183290800
29	5000	2250000	107100	25400	507500	0.0	5544000	0	5544000	188834800
30	5000	2250000	107100	25400	507500	0.0	5474900	0	5474900	194309700
TOT	150000	67500000	3213000	762000	15225000		194309700	0	194309700	
LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST										
DOLLARS PER TON OF COAL BURNED							60.48	0.0	60.48	
MILLS PER KILOWATT-HOUR							2.59	0.0	2.59	
CENTS PER MILLION BTU HEAT INPUT							287.87	0.0	287.87	
DOLLARS PER TON OF SULFUR REMOVED							255.00	0.0	255.00	
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS							57798000	0	57798000	
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT										
DOLLARS PER TON OF COAL BURNED							65.01	0.0	65.01	
MILLS PER KILOWATT-HOUR							2.79	0.0	2.79	
CENTS PER MILLION BTU HEAT INPUT							309.48	0.0	309.48	
DOLLARS PER TON OF SULFUR REMOVED							274.18	0.0	274.18	

TABLE C-23

LIME/LIMESTONE SLUDGE DISPOSAL - CHEMFIX PROCESS, 1500 MW NEW UNIT, 3.5% S, 7000 HRS CONSTANT ONSTEAM, REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 25453000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	7000	94500000	4500000	106800	2131500	0.0	16943900	0	16943900	16943900
2	7000	94500000	4500000	106800	2131500	0.0	16828100	0	16828100	33772000
3	7000	94500000	4500000	106800	2131500	0.0	16712200	0	16712200	50484200
4	7000	94500000	4500000	106800	2131500	0.0	16596400	0	16596400	67080600
5	7000	94500000	4500000	106800	2131500	0.0	16480500	0	16480500	83561100
6	7000	94500000	4500000	106800	2131500	0.0	16364700	0	16364700	99925800
7	7000	94500000	4500000	106800	2131500	0.0	16248900	0	16248900	116174700
8	7000	94500000	4500000	106800	2131500	0.0	16133000	0	16133000	132307700
9	7000	94500000	4500000	106800	2131500	0.0	16017200	0	16017200	148324900
10	7000	94500000	4500000	106800	2131500	0.0	15901300	0	15901300	164226200
11	7000	94500000	4500000	106800	2131500	0.0	15785500	0	15785500	180011700
12	7000	94500000	4500000	106800	2131500	0.0	15669700	0	15669700	195681400
13	7000	94500000	4500000	106800	2131500	0.0	15553800	0	15553800	211235200
14	7000	94500000	4500000	106800	2131500	0.0	15438000	0	15438000	226673200
15	7000	94500000	4500000	106800	2131500	0.0	15322100	0	15322100	241995300
16	7000	94500000	4500000	106800	2131500	0.0	15206300	0	15206300	257201600
17	7000	94500000	4500000	106800	2131500	0.0	15090400	0	15090400	272292000
18	7000	94500000	4500000	106800	2131500	0.0	14974600	0	14974600	287266600
19	7000	94500000	4500000	106800	2131500	0.0	14858800	0	14858800	302125400
20	7000	94500000	4500000	106800	2131500	0.0	14742900	0	14742900	316868300
21	7000	94500000	4500000	106800	2131500	0.0	14627100	0	14627100	331495400
22	7000	94500000	4500000	106800	2131500	0.0	14511200	0	14511200	346006600
23	7000	94500000	4500000	106800	2131500	0.0	14395400	0	14395400	360402000
24	7000	94500000	4500000	106800	2131500	0.0	14279600	0	14279600	374681600
25	7000	94500000	4500000	106800	2131500	0.0	14163700	0	14163700	388845300
26	7000	94500000	4500000	106800	2131500	0.0	14047900	0	14047900	402893200
27	7000	94500000	4500000	106800	2131500	0.0	13932000	0	13932000	416825200
28	7000	94500000	4500000	106800	2131500	0.0	13816200	0	13816200	430641400
29	7000	94500000	4500000	106800	2131500	0.0	13700300	0	13700300	444341700
30	7000	94500000	4500000	106800	2131500	0.0	13584500	0	13584500	457926200
TOT	210000	2835000000	135000000	3204000	63945000		457926200	0	457926200	
LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST										
DOLLARS PER TON OF COAL BURNED							3.39	0.0	3.39	
MILLS PER KILOWATT-HOUR							1.45	0.0	1.45	
CENTS PER MILLION BTU HEAT INPUT							16.15	0.0	16.15	
DOLLARS PER TON OF SULFUR REMOVED							142.92	0.0	142.92	
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS							133464500	0	133464500	
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT										
DOLLARS PER TON OF COAL BURNED							3.57	0.0	3.57	
MILLS PER KILOWATT-HOUR							1.53	0.0	1.53	
CENTS PER MILLION BTU HEAT INPUT							17.02	0.0	17.02	
DOLLARS PER TON OF SULFUR REMOVED							150.55	0.0	150.55	

TABLE C-24

LIME/LIMESTONE SLUDGE DISPOSAL - CHEMFIX PROCESS, 1500 MW NEW UNIT, 3.5% S, 5000 HRS CONSTANT ONSTEAM, REGULATED CO. ECONOMICS

FIXED INVESTMENT: $ 24066000

YEARS AFTER POWER UNIT START	ANNUAL OPERATION, KW-HR/KW	POWER UNIT HEAT REQUIREMENT, MILLION BTU /YEAR	POWER UNIT FUEL CONSUMPTION, TONS COAL /YEAR	SULFUR REMOVED BY POLLUTION CONTROL PROCESS, TONS/YEAR	BY-PRODUCT RATE, EQUIVALENT TONS/YEAR WASTE SOLIDS	NET REVENUE, $/TON WASTE SOLIDS	TOTAL OP. COST INCLUDING REGULATED ROI FOR POWER COMPANY, $/YEAR	TOTAL NET SALES REVENUE, $/YEAR	NET ANNUAL INCREASE (DECREASE) IN COST OF POWER, $	CUMULATIVE NET INCREASE (DECREASE) IN COST OF POWER, $
1	5000	67500000	3214300	76300	1522500	0.0	14417000	0	14417000	14417000
2	5000	67500000	3214300	76300	1522500	0.0	14301100	0	14301100	28718100
3	5000	67500000	3214300	76300	1522500	0.0	14185300	0	14185300	42903400
4	5000	67500000	3214300	76300	1522500	0.0	14069400	0	14069400	56972800
5	5000	67500000	3214300	76300	1522500	0.0	13953600	0	13953600	70926400
6	5000	67500000	3214300	76300	1522500	0.0	13837700	0	13837700	84764100
7	5000	67500000	3214300	76300	1522500	0.0	13721900	0	13721900	98486000
8	5000	67500000	3214300	76300	1522500	0.0	13606100	0	13606100	112092100
9	5000	67500000	3214300	76300	1522500	0.0	13490200	0	13490200	125582300
10	5000	67500000	3214300	76300	1522500	0.0	13374400	0	13374400	138956700
11	5000	67500000	3214300	76300	1522500	0.0	13258500	0	13258500	152215200
12	5000	67500000	3214300	76300	1522500	0.0	13142700	0	13142700	165357900
13	5000	67500000	3214300	76300	1522500	0.0	13026800	0	13026800	178384700
14	5000	67500000	3214300	76300	1522500	0.0	12911000	0	12911000	191295700
15	5000	67500000	3214300	76300	1522500	0.0	12795200	0	12795200	204090900
16	5000	67500000	3214300	76300	1522500	0.0	12679300	0	12679300	216770200
17	5000	67500000	3214300	76300	1522500	0.0	12563500	0	12563500	229333700
18	5000	67500000	3214300	76300	1522500	0.0	12447600	0	12447600	241781300
19	5000	67500000	3214300	76300	1522500	0.0	12331800	0	12331800	254113100
20	5000	67500000	3214300	76300	1522500	0.0	12216000	0	12216000	266329100
21	5000	67500000	3214300	76300	1522500	0.0	12100100	0	12100100	278429200
22	5000	67500000	3214300	76300	1522500	0.0	11984300	0	11984300	290413500
23	5000	67500000	3214300	76300	1522500	0.0	11868400	0	11868400	302281900
24	5000	67500000	3214300	76300	1522500	0.0	11752600	0	11752600	314034500
25	5000	67500000	3214300	76300	1522500	0.0	11636700	0	11636700	325671200
26	5000	67500000	3214300	76300	1522500	0.0	11520900	0	11520900	337192100
27	5000	67500000	3214300	76300	1522500	0.0	11405100	0	11405100	348597200
28	5000	67500000	3214300	76300	1522500	0.0	11289200	0	11289200	359886400
29	5000	67500000	3214300	76300	1522500	0.0	11173400	0	11173400	371059800
30	5000	67500000	3214300	76300	1522500	0.0	11057500	0	11057500	382117300
TOT	150000	2025000000	96429000	2289000	45675000		382117300	0	382117300	
LIFETIME AVERAGE INCREASE (DECREASE) IN UNIT OPERATING COST										
DOLLARS PER TON OF COAL BURNED							3.96	0.0	3.96	
MILLS PER KILOWATT-HOUR							1.70	0.0	1.70	
CENTS PER MILLION BTU HEAT INPUT							18.87	0.0	18.87	
DOLLARS PER TON OF SULFUR REMOVED							166.94	0.0	166.94	
PROCESS COST DISCOUNTED AT 11.6% TO INITIAL YEAR, DOLLARS							112489900	0	112489900	
LEVELIZED INCREASE (DECREASE) IN UNIT OPERATING COST EQUIVALENT TO DISCOUNTED PROCESS COST OVER LIFE OF POWER UNIT										
DOLLARS PER TON OF COAL BURNED							4.22	0.0	4.22	
MILLS PER KILOWATT-HOUR							1.81	0.0	1.81	
CENTS PER MILLION BTU HEAT INPUT							20.08	0.0	20.08	
DOLLARS PER TON OF SULFUR REMOVED							177.62	0.0	177.62	